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Current Landscape of Ecological Momentary Assessment (Real-Time Data) Methodology in Cancer Research: A Systematic Review

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ABSTRACT

Objective: To critically synthesize and describe the use and methods of ecological momentary assessment (EMA) in cancer research.
Data Sources: A systematic review was conducted and has been reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) Guideline. Electronic databases (APA PsycINFO, CINAHL, Cochrane Central Register of Controlled Trials, MEDLINE, Scopus, and Web of Science Core Collection) were searched using a variety of keywords and subject headings by an expert systematic review librarian. All publications were double screened by two reviewers using predetermined exclusion and inclusion criteria throughout the full review process. The review used Covidence Systematic Review Software. Methodological quality assessment and data extraction were performed. A narrative synthesis was conducted to examine the aim for EMA, the characteristics of the study samples, the EMA sampling procedures, EMA completion rates, outcome measures, and any implications of findings for survivorship care.
Conclusion: A total of 42 EMA studies in cancer were included. Most studies used an electronic mobile device to capture EMA data apart from several that used paper diaries. Existing studies were found to have significant heterogeneity in methods and widely varying approaches to design and self-report measurements. While EMA in cancer research holds significant promise to advance cancer care research into the future by increasing ecological validity and reducing retrospective bias and can capture the unique idiographic within-person change over time, in real-time, further research is needed to develop standardized EMA self-report questionnaires.
Implications for Nursing Practice: This is the first comprehensive systematic review to describe the use and methods of EMA in cancer research. There is significant heterogeneity in methods and widely varying approaches to design and self-report measurements in EMA cancer research. People affected by cancer found taking part in EMA studies reported benefit from the experience. However, researchers must engage with cancer survivors in the development and co-design of future EMA questionnaires to ensure relevant and acceptability of EMA data collection protocols.

Introduction

Historically, assessment of patient experiences has been conducted by standardized patient reported outcome instruments and qualitative study designs, both of which are prone to retrospective questioning and retrospective memory recall bias. When people are asked how they felt or how often some event occurred commonly they will rely on heuristic strategies or will rely on experiences that are recent or important for them to estimate an answer.[1] Therefore, the real-life validity of data presented from existing studies using these designs is unknown.[2] Within the suite of self-report measures the ecological momentary assessment (EMA) methodology captures real-time, real-world, self-reports in participants naturalistic environments.[3-5] The EMA method is uniquely designed to capture momentary data collection in participants natural home environments at multiple time points, and there are several cardinal advantages within cancer research. First, EMA eliminates retrospective memory recall bias completely, because it captures data in real-time in that moment for the participant rather than a summary of responses based upon memory. Second, the EMA data collection

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occurs in the participants' home, which in turn increases the ecological validity of the assessments. Third, because EMA captures repeated detailed in-depth assessments (which may include several times in the course of a day, weeks, or even months) about quality of life, symptoms (frequency, bother, and severity), and behaviors, it can identify individuals unique experiences, and expose subtleties in behaviors, symptoms, and cognitions over time.[6] Finally, EMA can provide valuable insights in time-varying relationships and dynamics between cognition, behavior, and symptoms and its correlations.[1,2,4]

EMA is now being increasingly used to assess behaviors and health-related symptoms in a variety of conditions, including pain,[7] asthma,[8] heart disease,[9] arthritis,[10] stress-related diseases,[11] and now cancer.[12,13] Many individuals affected by cancer can experience significant suffering and distress as a consequence of cancer and its associated treatments.[14] In the main, evaluations of patient sensitive outcomes within cancer are based on retrospective patient-reported outcome measures (PROMs) and qualitative evaluations which have provided insight into the past experiences, but noteworthy, not their current present reality in the context of cancer. There are many advantages of EMA for cancer care research, and there has been an observed increase in the use of technologies to implement EMA which has translated to a large uptake of EMA studies in cancer. However, it is important to point out that EMA is a highly specialized research method and knowledge of its implementation in the cancer context is important. For example, the EMA method can be interval, signal, and event contingent protocols.[1,3,5] An interval contingent design requires the participant to record their self-report at predetermined intervals. A signal contingent data collection protocol will prompt the participant by a signaling alert (that is, an audio sound or vibrations) at fixed or random time intervals. Whereas an event contingent protocol is based on incidents of interest in phenomenon whereby participants will complete a self-report each time a particular experience of interest occurs. Furthermore, little is known about the effects of EMA among people affected by cancer and whether it causes distress triggered by the constant reminders of living with cancer and thereby noting the associated negative impacts on quality of life.[15] Existing research has identified that such approaches can expose methodological complexities in cancer research.[15] These complexities can include: 1) reactance, 2) habituation, 3) increased complexity, and 4) gradual entrainment.[1,15] Reactance can occur if the participants change their behavior as a result of completing the EMA. A reactive measure is one that changes the phenomenon it is designed to assess. This effect is desirable if the measurement occurs as part of an intervention aimed at changing behavior but is problematic when the measurement designed over time is used only to assess the phenomenon of interest. Habituation has been described as the development of habitual responses when completing the self-report, that is, a tendency to skim over questions that rarely apply to the participants' experience.[1] Increased complexity refers to the development of a more advanced understanding of a particular construct as a result of repeated exposure to the surveyed domain, whereas gradual entrainment has been described as participants changing their conceptualization of their illness to fit with those measured in the self-report. It is well recognized that the sampling of the EMA places significant burden on participants to complete, and therefore important consideration must be taken for people affected by cancer.

This systematic review aimed to summarize and comprehensively describe the use and methods of EMA in cancer research. The main purpose of this systematic review was to examine the aim for EMA, the characteristics of the study samples, the EMA sampling procedures, EMA completion rates, outcome measures, and any implications of findings for supportive care. The rationale for this review is that by reporting these aspects improvements can be made in reproducibility and assist in future research to clarify the significance of EMA design decisions in the context of cancer.

Method

A systematic review has been reported according to the referred reporting items for systematic reviews.[16] This systematic review was conducted according to a protocol registered with PROSPERO (CRD42022379986).

Search Strategy

A systematic literature search was conducted by an expert systematic review librarian. The following electronic databases were searched: APA PsycINFO, CINAHL, Cochrane Central Register of Controlled Trials, MEDLINE, Scopus, and Web of Science Core Collection. Searches used a variety of keywords and subject headings, for example (ecological momentary assessment, EMA, electronic device, electronic diaries, self-report, e-PREMS, e-PROMs, daily diary, mobile, device, technology, etc.) See Supplementary Table 1 for the full record of database searches. The goal was to identify all previous EMA studies in cancer research and the search terms were inclusive to capture all EMA studies whereby the authors themselves may not have mentioned EMA to limit any unintentional exclusion of studies in the current systematic review. Electronic databases were searched from inception until June 2023.

Eligibility Criteria

Study design

All studies in cancer that had reference to EMA were included and related EMA methods. All commentaries, editorials, and studies that did not present empirical data or studies that captured real-time assessments of self-reports as part of an intervention were excluded from the review. The included studies had one or more assessments per day.

Types of participants

All participants affected by cancer, irrespective of age, cancer type, stage, treatment, time since diagnosis, or treatment were included. All other clinical population groups were excluded.

Types of outcomes

All assessments of variables captured in EMA studies were included irrespective of the context of cancer. Outcomes included the characteristics of the study samples, the EMA sampling procedures, EMA completion rates, outcome measures, and implications of findings for supportive care.

Selection of studies

Following the search, all identified citations were exported to Endnote and then imported into Covidence systematic review software. All duplicates were removed in Covidence. All titles and abstracts were screened independently by two reviewers (CP and LA). Then all full-text articles were assessed according to the inclusion and exclusion criteria by both reviewers. Throughout the review process, all conflicts were resolved by discussion. Full-text studies that did not meet the inclusion criteria were excluded with reasons, and the study selection process was described using the PRISMA flow diagram.[16]

Data extraction

Data were tabulated in a study characteristics table, which included: sample characteristics (sample size, age, gender, cancer

tumor, stage of the disease, time since diagnosis or treatment, comparison groups, and country of investigation), EMA data collection methods, the type of device, application name and operating system, the EMA study schedule, monitoring periods which reported on monitoring duration (number of days) and period (number of times per day), participation rate, attrition rate, missing data, incentives, outcome measures, and any implications of findings for supportive care. Data were extracted by one reviewer and quality-checked by a second reviewer. The data extraction table was designed using the adapted STROBE Checklist for Reporting EMA Studies (CREMAS).[17] Data extraction was conducted by two review authors and cross-checked to ensure quality assurance processes were maintained during this activity.

Data synthesis

A narrative synthesis approach was used to summarize the evidence.[18] This process involved a tabulation of primary research studies, identifying similarities and differences within and between studies, and seeking explanations for these differences. The analysis implicated the following steps: data reduction and subgroup classification based on EMA characteristics and the review aims, narrative data comparison (iterative process of making comparisons and identifying relationships), and, finally, drawing conclusions. Data synthesis was conducted by two review authors (CP and LA).

Methodological Quality Assessment

A methodological quality assessment was undertaken using the mixed-methods assessment tool (MMAT).[19] Noteworthy, previous EMA reviews[6,7,12,13] have not included a quality assessment of their included studies; therefore, little is known about the quality of existing EMA studies. A further methodological quality assessment consideration is that EMA studies do not have questionnaires readily available to researchers with demonstrated reliability or validity. In the main they have been developed from existing retrospective standardized PROMs. Given these considerations this review also used the COSMIN method for evaluation of self-report PROMs[20] to assess reliability and validity of the EMA PROMs used in the included studies.

Findings

The results of the electronic database search identified 506 publications, a further 6 publications were identified by citation searching, and 42 studies were included, see Fig 1. Existing EMA studies were conducted in United States of America (n = 28), United Kingdom (n = 3), Spain (n = 1), The Netherlands (n = 2), Switzerland (n = 1), South Korea (n = 1), New Zealand (n =1), Canada (n = 1), Australia (n = 1), Mexico (n =1), Germany (n = 1), and multicountry (n = 1) (see Table 1). Overall, the methodological quality of the included studies was good (see Table 2). However, the assessment of EMA PROMs according to COSMIN[20] criteria underscored that none of the included studies reported validity or reliability in any of their measures (see Supplementary Table 2), and this should be an important focus for future research to move the EMA field forward.

Aim of EMA in Cancer

It was apparent that existing EMA studies in cancer had a broad and heterogeneous focus in research aims. Studies used EMA to measure and assess cognitive predictors of physical activity[21-27] and sleep,[28] whereas other studies measured thoughts, affect and

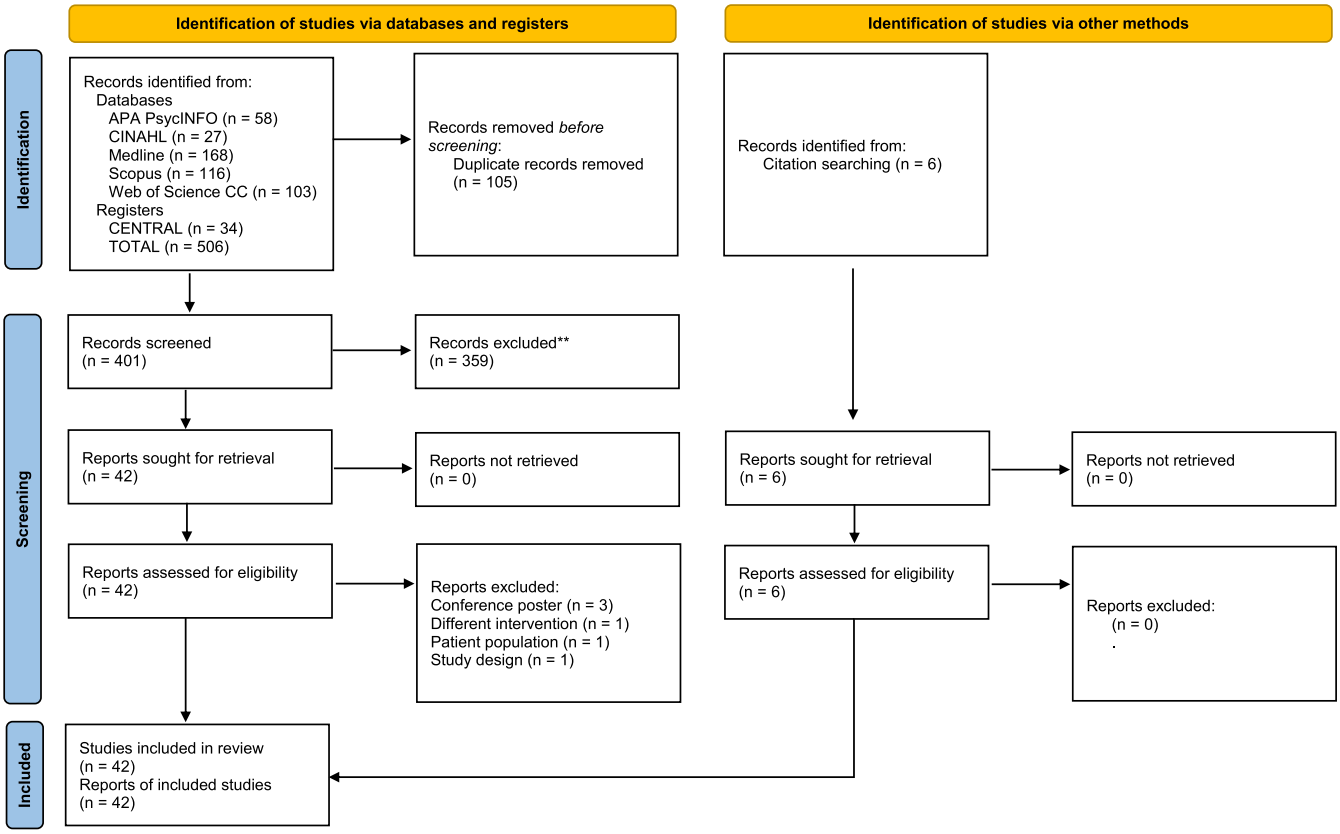

Figure 1. PRISMA Flow Diagram.

Table 1
Study Characteristics.

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Abraham et al, 2015	To explore cross-cultural experiences of women taking estrogen plus progestin therapies (EPT) and develop a symptom-based electronic diary (eDairy) and impact questionnaire for EPT-related breast symptoms	Sample size: N=20 Cancer Type: Breast cancer Treatments: EPT Cancer Stage: Not specified Age: Postmenopausal Gender: women Treatment trajectory: Country of origin: USA	Primary outcome: Descriptions of breast sensations associated with EPT and impact on HRQL Secondary outcomes: Experience of completing eDiary	Device: hand-held electronic device (eDiary) Application name: BPT-DD Operation system: Not specified	Monitoring periods: 1 time per day Duration: 12−14 days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 18/20 Attrition: Not specified Missing data: Not specified Incentive: Not specified
Aigner et al 2016	To examine the association between pain and smoking among cancer patients with pain enrolled in a smoking cessation treatment program	Sample size: N= 34 Cancer Type: Breast, lung, and head and neck Treatments: Chemotherapy, hormone therapy, radiation therapy, and multiple therapies Cancer Stage: Age: 52 years (SD 10−30) Gender: 55% women Treatment trajectory: Country of origin: USA	Primary outcome: Immediate precipitants of smoking behavior among cancer patients enrolled in cessation treatment Secondary outcomes:	Device: palmtop personal computer (PPC) Application name: 20 HP iPAQ H1945 PPCs Operation system: Window Mobile 5	Monitoring periods: 1 time per day Duration: 2-weeks Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 73% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Ainsworth et al, 2018	To evaluate the acceptability of the Life in a Day app for time use among breast cancer survivors	Sample size: N=40 Cancer Type: Breast cancer Treatments: Surgery, radiation and/or Chemotherapy Cancer Stage: I, II, IIIa Age: 55 years (SD 8) Gender: 100% female Treatment trajectory: Not specified Country of origin: USA	Primary outcome: Life in a Day app user experience Secondary outcomes: Shifts in time use	Device: Smartphone Application name: Life in a Day Operation system: iOS or Android	Monitoring periods: Log all activities 24-hours a day Duration: 5 days Data sampling: Event contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 100% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Aldaz et al, 2019	The aim of the study was to explore the covariation of daily fluctuations in treatment-related distress and well-being with illness uncertainty and experiential avoidance of uncertainty-related thoughts and/or emotions in patients with cancer across a week of oncology treatment with curative intent	Sample size: N=31 Cancer Type: Mixed cancers Treatments: Chemotherapy, radiotherapy, Herceptin, hormonal therapy and surgery Cancer Stage: I−IV Age: 60 years (SD 14) Gender: 61.3% female Treatment trajectory: Country of origin: New Zealand	Primary outcome: Daily treatment-related distress and well-being Secondary outcomes: daily illness uncertainty and experiential avoidance	Device: Paper-based daily diary Application name: N/A Operation system: N/A	Monitoring periods: once a day in the evening Duration: 7 days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 87.1% Attrition: Not specified Missing data: 1.8% Incentive: $20 grocery voucher
Auster- Gussman et al, 2022	To use EMA assessments of concurrent and previous day exercise self−efficacy, physical outcome expectations, psychological outcomes expectations, and goal setting combined with objectively measured moderate−vigorous and light intensity physical activity to prospectively examine the relationship between these SCT constructs and daily physical activity	Sample size: N= 67 Cancer Type: Breast cancer Treatments: Chemotherapy Cancer stage: I, II, III Age: 48.5 years (SD 10.3) Gender: 100% female Treatment trajectory: During treatment Country of origin: USA	Primary outcome: Social cognitive theory Secondary outcomes: Not specified	Device: AntiGraph Application name: wGT3X−BT, AntiGraph Corporation Operation system: Device: SMS link- online questionnaire Application name: Not specified Operation system:	AntiGraph Monitoring periods: Continuous monitoring Duration: 10 days Data sampling: Interval contingent Prompts frequency: No Prompt interval: Not specified Snooze option: Not specified SMS: EMA Monitoring periods: am and pm Duration: 3 × 10 days Data sampling: signal contingent Prompts frequency: 3 Prompt interval: 15 minutely Snooze option: Not specified	Participation rate: 84% Attrition: Not specified Missing data: Not specified Incentive: Not specified

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Badr et al, 2006	To determine the feasibility of using electronic diaries to assess physical activities and cancer symptom burden in breast cancer (after completing chemotherapy) and ovarian cancer (still undergoing chemotherapy).	STUDY 1 Sample size: N=23 Cancer Type: Breast cancer Treatments: Chemotherapy Cancer Stage: I, II, III Age: 56.7 years (SD 10.2) Gender: Not specified Treatment trajectory: Post treatment STUDY 2 Sample size: N=42 Cancer Type: Ovarian cancer Treatments: Carboplatin, Paclitaxel or both Cancer Stage: Stage III or IV Age: 58.3 years (SD 11.1) Gender: 100% Female Treatment trajectory: Active treatment Country of origin: USA	Primary outcome: Physical activity and cancer symptoms Secondary outcomes: Mood states	STUDY 1 Device: Electronic Diary Application name: Palm M100 or M105 and Palm Zires Operation system: Not specified STUDY 2 Device: Electronic Diary Application name: Palm M100 or M105 and Palm Zires Operation system: Not specified + weekly retrospective questionnaires for physical function and emotional wellbeing	STUDY 1 Monitoring periods: 4 times per day Duration: 7 days Data sampling: Signal contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified STUDY 2 Monitoring periods: 4 times per day Duration: 1 Chemotherapy cycle-approx. 3 weeks Data sampling: Signal contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	STUDY 1 Participation rate: 69% Attrition: Not specified Missing data: Not specified Incentive: Not specified STUDY 2 Participation rate: 79% (study); 86% (assessments) Attrition: 26% Missing data: Not specified Incentive: Not specified
Badr et al, 2010	To assess the unique effects of patient and partner pain appraisals on mood and relationship function	Sample size: N= 59 couples Cancer Type: Metastatic breast cancer Treatments: Cancer Stage: stage 4 Age: 49 years (SD 10.76) and partner 51 years (SD 11.51) Gender: women; partners male Treatment trajectory: Not reported Country of origin: USA	Primary outcome: Patient's pain, and partners mood, the provision/receipt of social support Secondary outcomes: The degree to which cancer interfered with their relationship	Device: ePalm Tungsten E or E2 computers Application name: Not specified Operation system: Not specified	Monitoring periods: 6 times per day Duration: 14 days Data sampling: signal contingent Prompts frequency: A stratified-random sampling scheme Prompt interval: alarm signal Snooze option: Not specified	Participation rate: 69.78% Attrition: Missing data: 34% Incentive: $80 gift card
Badr et al, 2013	To evaluate whether social-cognitive theory variables, as measured by questionnaire and ecological momentary assessment, predicted exercise in endometrial cancer survivors	Sample size: N=97 Cancer Type: Endometrial cancer Treatments: Surgery, radiation and/or Chemotherapy Cancer Stage: I, II, IIIa Age: 57 years (SD not specified) Gender: 100% female Treatment trajectory: Not specified Country of origin: USA	Primary outcome: Self-efficacy Secondary outcomes: Physical activity	Device: Hand-held computer Application name: Not specified Operation system: Hewlett-Packard iPAQ RX1950 Device: Accelerometer Application name: GT1M Operation system: ActiGraph	Monitoring periods: Wake, sleep times and physical activity participation Duration: 4 × 10/12 days (baseline, 2 months, 4 months, and 6 months) Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 97% Attrition: Not specified Missing data: Not specified Incentive: $40 for laboratory assessments; EMA incentive prorated on compliance $5−$30 per period.
Basen-Engquist et al, 2013	To evaluate whether social-cognitive theory variables, as measured by questionnaire and ecological momentary assessment, predicted exercise in endometrial cancer survivors	Sample size: N=97 Cancer Type: Endometrial cancer Treatments: Surgery, radiation and/or Chemotherapy Cancer Stage: I, II, IIIa Age: 57 years (SD not specified) Gender: 100% female Treatment trajectory: Not specified Country of origin: USA	Primary outcome: Self-efficacy Secondary outcomes: Physical activity	Device: Hand-held computer Application name: Not specified Operation system: Hewlett-Packard iPAQ RX1950 Device: Accelerometer Application name: GT1M Operation system: ActiGraph	Monitoring periods: Wake, sleep times and physical activity participation Duration: 4 × 10/12 days (baseline, 2 months, 4 months, and 6 months) Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 97% Attrition: Not specified Missing data: Not specified Incentive: $40 for laboratory assessments; EMA incentive prorated on compliance $5-$30 per period.

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Belcher et al, 2011	Examined within-couple daily support processes and their association with daily relationship well-being in couples coping with early-stage breast cancer.	Sample size: N= 45 Cancer Type: Breast cancer Treatments: Lumpectomy or mastectomy followed by radiation or chemotherapy or hormonal therapy Cancer Stage: I, II, IIIa, or ductal carcinoma Age: 53 (SD 9.7) Gender: female patients and male partners Treatment trajectory: Post treatment Country of origin: USA	Primary outcome: daily relationship intimacy reported by each partner Secondary outcomes: Not specified	Device: Internet based Application name: Not specified Operation system: Not specified	Monitoring periods: once per day, in the evening Duration: 7-days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 70% Attrition: Missing data: Incentive: $25 on the return of the questionnaire and $5 for each diary completed, $5 bonus for completion of all seven diaries ($130)
Buck & Morley 2006	To investigate the use of attentional strategies in a naturalistic setting within the complex and variable context of cancer pain, where the threat value of pain was expected to be high	Sample size: N= 26 Cancer Type: Not specified Treatments: Not reported Cancer Stage: Not reported Age: 55.5 years (SD 11.5) Gender: 12 male and 14 female Treatment trajectory: Palliative Country of origin: UK	Primary outcome: measures of pain, intensity, affect, coping, coping efficacy, and the novelty and predictability of pain, Secondary outcomes: measure of catastrophizing	Device: Paper based diary Application name: N/A Operation system: N/A	Monitoring periods: 3 time per day Duration: 10-days Data sampling: Event contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 96.5% Attrition: 4 participants Missing data: Not specified Incentive: Not specified
Campbell et al, 2022	To evaluate the feasibility of an intensive symptom and function monitoring protocol before and during a full regimen of 6 cycles of chemotherapy treatment for gynecological cancers	Sample size: N= 25 Cancer Type: Gynecological - ovarian, uterine/ endometrial, or cervical cancer Treatments: Platinum and Taxane Chemotherapy Cancer Stage: III and IV Age: 60.6% Gender: 100% female Treatment trajectory: During treatment Country of origin: USA	Primary outcome: Daily symptom and function monitoring Secondary outcomes: sense of symptom controllability	Device: Paper and pencil diary Application name: N/A Operation system: N/A Device: ActiWatch - Legacy ActiGraph Application name: Not specified Operation system: Not specified	Monitoring periods: daily Duration: 6 × 21 day cycles Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified Monitoring periods: Continuous for 7 days Duration: 6 × 7 days (3 days before chemotherapy and 4 days after chemotherapy) Data sampling: Continuous Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 83% Attrition: 4 participants Missing data: increased with subsequent cycles- percentage not specified Incentive: $20 for each study assessment completed and $1 for each daily diary completed. Potential total $240
Curran et al, 2004	To examine the diurnal patterns of fatigue in a sample of breast cancer survivors.	Sample size: N= 74 (25 BC, 24 BBP and 25 HC) Cancer Type: Breast cancer Treatments: Chemotherapy and/or Radiation Cancer Stage: Stage 0, I, II and Benign Breast Problems Age: 48.2 (SD8.6) BC; 49.1 (SD8.2) BBP; 48.1 (SD 8.6) HC Gender: 100% Female Treatment trajectory: Post treatment Country of origin: USA	Primary outcome: Fatigue Secondary outcomes: Pain, Mood and Activity	Device: Daily Diary and Pedometer Application name: Not specified Operation system: Not specified	Monitoring periods: 4 times per day Duration: 6 days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: Not specified Attrition: Not specified Missing data: less than 1% Incentive: $50

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Escudero-Vilaplana et al, 2022	To assess the usability of the app eB2-ECOG concerning patient's characteristics, acceptability and satisfaction.	Sample size: N=106 Cancer Type: Unresectable or metastatic lung cancer, gastrointestinal stromal tumor, sarcoma or head and neck cancer Treatments: Systemic anticancer therapies Cancer Stage: Not specified Age: 64.7 (SD 15.7) Gender: 63.8% Male Treatment trajectory: Not specified Country of origin: Spain	Primary outcome: ECOG-PS and HRQoL Secondary outcomes: Patient's acceptability and satisfaction	Device: Smartphone Application name: eB2-ECOG Operation system: Android (version 4.4 or higher) or iOS (version 10 or higher)	Monitoring periods: 24-hour cycle Duration: continuous monitoring over 6 months Data sampling: Continuous contingent/ Event contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 89% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Glaus et al, 1993	The aim of the study (a) to develop a simple, self-assessment tool for measurement of fatigue over daily periods, (b) to explore symptoms and levels of fatigue in cancer patients.	Sample size: N=20 Cancer Type: Malignant lymphoma, myeloma, breast cancer, lung cancer and other solid tumors Treatments: Chemo- or chemo-hormone therapy, or radiotherapy Cancer Stage: Age: 54 years (SD 14.73) Gender: 13/20 female Treatment trajectory: Not specified Country of origin: Switzerland	Primary outcome: measurement of fatigue over daily periods Secondary outcomes: manifestation of symptoms and levels of fatigue in cancer patients	Device: Fatigue assessment Scale – paper based Application name: N/A Operation system: N/A	Monitoring periods: 4 times per day Duration: 7 days Data sampling: Interval contingent Prompts frequency: N/A Prompt interval: N/A Snooze option: N/A	Participation rate: Not specified Attrition: Not specified Missing data: Not specified Incentive: Not specified
Grassi et al, 2015	To prospectively explore the association of psychosocial variables, including emotional distress, maladaptive coping styles and the doctor-patient relationship, with CINV and QoL among cancer outpatients	Sample size: N = 302 Cancer Type: Gastrointestinal, breast, genitourinary, respiratory and blood cancers Treatments: Chemotherapy alone or in combination with hormone therapy or radiotherapy or both Cancer Stage: local or locoregional 55.6% and metastatic 44.4% Age: Adult population 18-65 years Gender: 59.6% female Treatment trajectory: Country of origin: Austria, Italy and Spain	Primary outcome: CINV Secondary outcomes: QoL	Device: Daily diary – paper based Application name: N/A specified Operation system: N/A	Monitoring periods: Daily Duration: 5 days after chemotherapy Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 80.9% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Hacker et al, 2006	To examine the patterns of fatigue, physical activity, health status, and quality of life before and after high-dose chemotherapy and hematopoietic stem cell transplantation (HSCT) and to examine the feasibility of obtaining real-time fatigue and physical activity data	Sample size: N = 17 Cancer Type: Lymphoma Chronic myelogenous, leukemia Acute myelogenous, leukemia Acute lymphocytic, leukemia Multiple myeloma, Myelofibrosis, and Plasma cell leukemia Treatments: High-dose chemotherapy followed by hematopoietic stem cell transplantation Cancer Stage: Age: 48.65 years (SD not specified) Gender: Female 55% Treatment trajectory: Not specified Country of origin: USA	Primary outcome: fatigue, physical activity, health status, and QOL before and after high-dose chemotherapy and HSCT Secondary outcomes: determine the feasibility of using the	Device: Actiwatch-Score Application name: Mini Mitter Company Operation system: Not specified	AntiGraph Monitoring periods: continuous Duration: 10 days Data sampling: continuous Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified EMA- data entered into Actiwatch-score Monitoring periods: 3 times per day Duration: 10 days Data sampling: interval; contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 87% Attrition: Not specified Missing data: Not specified Incentive: Not specified

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Hacker et al, 2007	To EMA its applicability to capture real-time, real-world assessments of fatigue in cancer patients receiving intensive therapy.	Sample size: N=20 Cancer Type: Hematological malignancies Treatments: High dose chemotherapy and Hematological stem cell therapy Cancer Stage: Not specified Age: 48.7 years (range 23-64 years) Gender: 55% female Treatment trajectory: Not specified Country of origin: USA	Primary outcome: Response rate Secondary outcomes: Fatigue assessment	Device: Actiwatch-score Application name: Not specified Operation system: Mini Mitter	Monitoring periods: 3 times per day Duration: 3 days before receiving HSCT and 3 days (total 6 days) after receiving HSCT Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 87% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Hacker et al, 2017	To explore the relationship between real-time fatigue and free-living physical activity.	Sample size: N=50 (25 HTC cancer survivors with persistent fatigue; 25 HC) Cancer Type: Hematological malignancies Treatments: Hematopoietic stem cell transplantation, including chemotherapy and or radiation Cancer Stage: III and IV Age: 52.8 (SD11.8) Gender: 56% men (N=28); 44% female (N=22) Treatment trajectory: Post treatment/ transplantation Country of origin: USA	Primary outcome: Fatigue Secondary outcomes: Physical Activity	Device: Wrist-worn Accelerometer Application name: Actiwatch-Score (Philips Respironics) Operation system: Actiware software (V.60)	Monitoring periods: 5 times per day Duration: 7 days Data sampling: Diurnal signal contingent; wake and sleep times event contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: Not specified Attrition: Not specified Missing data: approx. 50% (calculated by number of real-time fatigue scores) Incentive: Not specified
Hanisch et al, 2009	To identify the pathophysiology and evaluate treatments of hot flushes.	Sample size: N= 47 Cancer Type: Prostate cancer Treatments: Androgen deprivation therapy Cancer Stage: Not reported Age: 71 years (54-88 years) Gender: 100% Males Treatment trajectory: active treatment Country of origin: USA	Primary outcome: Record of hot flushes Secondary outcomes: Not specified	Device: Meditrace sliver/silver chloride electrodes connected to a Biolog monitor Application name: Not reported Operation system: Not reported Device: Paper diary Application name: N/A Operation system: N/A	Monitoring periods: Continuous Duration: 2 × 48 hours Data sampling: Patient prompted Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified Monitoring periods: 2 times per day Duration: 2 × 48 hours Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 87% Attrition: Not specified Missing data: 13% Incentive: Not specified Participation rate: 39/47 Attrition: Not specified Missing data: 17% Incentive: Not specified
Harnas et al, 2021	To illustrate how automated individual time series analyses can be applied to personalize CBT for cancer related fatigue in cancer survivors.	Sample size: N=3 Cancer Type: Breast cancer Treatments: Chemotherapy, Mastectomy, Radiotherapy and/ or Hormonal therapy Cancer Stage: Not specified (Curative) Age: 60 years, 56, year and 50 years Gender: 100% Female Treatment trajectory: Post treatment-still receiving hormone therapy Country of origin: The Netherlands	Primary outcome: Fatigue Secondary outcomes: Personalized Cognitive Behaviour Therapy	Device: Web-based questionnaire Application name: Not specified Operation system: Not specified	Monitoring periods: 5 times per day Duration: 2 × 14 days Data sampling: Signal contingent Prompts frequency: 30-mins reminder text message Prompt interval: Not specified Snooze option: 60 minutes to complete questionnaire	Participation rate: 100% Attrition: 0 Missing data: 6% (calculated) Incentive: Not specified

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Harper et al, 2012	To understand whether physicians, if provided with patient reported QOL data prior to clinic visits, will find this information clinically meaningful in evaluating patients' response to Phase I clinical cancer treatments.	Sample size: N= 30 patients, 3 physicians Cancer Type: Colorectal, breast or lung Treatments: Not reported Cancer Stage: 4 Age: 56.65 (SD 12.41) Gender: 47% female and 53% male Treatment trajectory: Active treatment Country of origin: USA	Primary outcome: Biomedical and patient-reported decision factors for physicians Secondary outcomes: Influences in treatment decisions	Device: electronic daily diary (EDD) device – web based Application name: Not specified Operation system: Not specified	Monitoring periods: Daily Duration: 52 days (SD = 31.5 Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 88% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Heathcote et al, 2022	To assess the feasibility, acceptability and validity of EMA as a research tool to study scanxiety among AYA survivors of childhood cancer.	Sample size: N=30 Cancer Type: Not specified Treatments: Not specified Cancer Stage: Not specified Age: 11-25 years Gender: Not specified Treatment trajectory: Completed active cancer treatment of curative intent Country of origin: USA	Primary outcome: Feasibility of EMA procedures Secondary outcomes: Validity of EMA surveys to capture scanxiety	Device: Smartphone Application name: Life data Operation system: Not specified	Monitoring periods: 3 times per day Duration: 5 days before, on the day of and 5 days after oncologist appointment (11 days) Data sampling: Signal contingent Prompts frequency: 3 reminders Prompt interval: 20 minute intervals Snooze option: Not specified	Participation rate: 83% Attrition: 1/30 Missing data: Not specified Incentive: $20 for baseline questionnaire, $2.50 for each completed EMA survey and a $25 bonus for all completed surveys
Kim et al, 2016	1. To evaluate the potential of a mobile mental- health tracker that uses three daily mental-health ratings as indications for depression 2. To discuss three approaches to data processing (ration, average and frequency) 3. To examine the impact of adherence on reporting using a mobile mental-health tracker and accuracy in depression screening	Sample size: N=85 Cancer Type: Breast cancer Treatments: Not specified Cancer Stage: Not specified Age: Not specified Gender: Not specified Treatment trajectory: Not specified Country of Origin: South Korea	Primary outcome: Mental health rating Secondary outcomes: Data processing approaches and adherence to screening	Device: Smart-phone Application name: Pit-a-Pat Operation system: Not specified	Monitoring periods: 3 times per day Duration: 14 days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 92% Attrition: 8% Missing data: 34.41% Incentive: Not specified
Langer et al, 2018	To examine intra- and interpersonal associations between communication (both enacted and perceived) and relationship satisfaction (RS) among patients with stage II to IV breast or colorectal cancer and their spouses.	Sample size: N=107 Cancer Type: Breast, colon or rectal cancer Treatments: Chemotherapy and/or hormone therapy Cancer Stage: II to IV Age: 51 Gender: 64.5% female patients and 37.4% female spouses Treatment trajectory: Active treatment Country of origin: USA	Primary outcome: Communication Secondary outcomes: Relationship satisfaction	Device: Smartphone Application name: lifedata-corp.com Operation system: iOS and Android	Monitoring periods: 2 times per day Duration: 14 days Data sampling: Signal contingent Prompts frequency: 2 hour window to complete Prompt interval: Not specified Snooze option: Not specified	Participation rate: 88.8% Attrition: Not specified Missing data: Not specified Incentive: $75 for >85% more completed responses OR $3 per notification completed if less than 85%
Müller et al, 2019	To investigate whether co-rumination is related to increases in daily relationship satisfaction in both members of the couple.	Sample size: N= 101 dyads Cancer Type: colorectal cancer Treatments: Cancer Stage: I, II, III and IV Age: 64.3 years (10.2) patient, 63.2 (SD 11.2) spouse Gender: 66.3% male partner, 33.7% male spouse Treatment trajectory: Not specified Country of origin: Netherlands	Primary outcome: co rumination Secondary outcomes: catastrophizing	Device: Electronic diary Application name: intuitive diary app Operation system: Not specified	Monitoring periods: 3 times a day Duration: 14 days Data sampling: Signal contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: Not specified Attrition: Not specified Missing data: Not specified Incentive: €50 gift card

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Otto et al, 2015	To examine daily intimacy and well-being in women with breast cancer and their intimate partners.	Sample size: N= 99 total (sample 1- 45 couples; sample 2-54 couples) Cancer Type: Breast cancer Treatments: Cancer surgery – lumpectomy or mastectomy Cancer Stage: I, II, IIIa stage Age: 52 years (SD 10.43) and spouses 54 years (SD = 11.94) Gender: patient women Treatment trajectory: post treatment Country of origin: USA	Primary outcome: Mechanism of capitalization Secondary outcomes: Social support	Device: Electronic dyadic daily diary Application name: Not specified Operation system: Not specified	Sample 1 Monitoring periods: Duration: 7-day daily diary Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified Sample 2 Monitoring periods: daily diary Duration: 10-day daily diary Data sampling: Event contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Sample 1 Participation rate: 82% Attrition: Not specified Missing data: Not specified Incentive: Not specified Sample 2 Participation rate: 81% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Paterson et al, 2019	To identify self-management strategies among men affected by prostate cancer	Sample size: N=12 Cancer Type: Prostate cancer Treatments: All therapies Cancer Stage: All stages Age: Over 18 Gender: 100% male Treatment trajectory: Not specified Country of origin: UK	Primary outcome: Self-management Secondary outcomes: Health-related quality of life	Device: Digital personal assistant Application name: Dell Axim X51 Operation system: Not specified	Monitoring periods: 3 times per day Duration: 31 days Data sampling: Signal contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: snooze for 5-60 minutes	Participation rate: 83.8% Attrition: Not specified Missing data: 1 participant Incentive: Not specified
Paterson et al, 2020	To identify the lived experiences of men affected by prostate cancer participating in an EMA study	Sample size: N=12 Cancer Type: Prostate cancer Treatments: All treatments Cancer Stage: All stages Age: 51-75 years Gender: 100% Male Treatment trajectory: Curative to palliative Country of origin: UK	Primary outcome: Lived experience	Device: Personal Digital Assistant Application name: Not specified Operation system: Not specified	Monitoring periods: 3 times per day Duration: One-month Data sampling: Signal contingent and event contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 100% Attrition: Not specified Missing data: Not specified Incentive: Not specified
Paxton et al, 2022	The aim of this study was to examine the associations of daily physical activity and sedentary behavior with symptom burden, pain interference, and fatigue among patients who were undergoing active cancer treatment.	Sample size: N= 22 Cancer Type: Not specified Treatments: surgery, chemotherapy or radiotherapy Cancer Stage: Localized- stage not specified Age: 57 years Gender: 73% women Treatment trajectory: active treatment Country of origin: USA	Primary outcome: treatment-related symptoms Secondary outcomes: lifestyle behaviors	Device: Daily diary Application name: printed survey Operation system: Not specified	Monitoring periods: Daily Duration: 10 days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 88% Attrition: Missing data: 12% Incentive: Not specified

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Phillips et al, 2020	To use EMA methodology to prospectively examine relationships between daily symptom burden and physical activity in breast cancer	Sample size: N= 67 Cancer Type: breast cancer Treatments: Chemotherapy Cancer Stage: I-III Age: 48.6 years (SD 10.3) Gender: 100% females Treatment trajectory: Active treatment Country of origin: USA	Primary outcome: Daily symptom burden Secondary outcomes: Physical activity	Device: AntiGraph accelerometer Application name: wGT3X-BT, AntiGraph Corporation, Pensacola, FL Operation system: ActiLife 6.13.3 Device: Smartphone Application name: EMA text prompts Operation system: Not specified	AntiGraph Monitoring periods: continuous 24hr per day Duration: 10 days Data sampling: Continuous Prompts frequency: 15 mins (open for 60 mins) Prompt interval: 2 hours Snooze option: Not specified EMA texts prompts Monitoring periods: 4 times per day Duration: 10 days Data sampling: Signal contingent Prompt interval: 15 mins (open for 60 mins) Prompt interval: 2 hours Snooze option: Not specified	Participation rate: 84% Attrition: Missing data: Not specified Incentive: Not specified
Pinto et al, 2021	To explore longitudinal trends in sedentary behavior (SB) using accelerometers and associated variables via EMA among breast cancer survivors.	Sample size: N=22 Cancer Type: Breast cancer Treatments: Not specified Cancer Stage: 0-3 Age: 51.5 Gender: 100% female Treatment trajectory: <5 years since diagnosis Country of origin: USA	Primary outcome: Sedentary behavior Secondary outcomes: Not specified	Device: Smartphone and AntiGraph accelerometer (GT3X) Application name: ilumivu Operation system: Android or Apple AND Device: AntiGraph accelerometer Application name: GT3X Operation system:	Monitoring periods: 5 times per day Duration: 5 × 7-day assessment periods at 0, 3, 6, 9, and 12 months Data sampling: 1x event contingent (wake up) and 4x signal contingent Prompts frequency: Prompt interval: Snooze option:	Participation rate: 78.62% Attrition: 9% Missing data: Not specified Incentive: 1. $10 data usage allowance 2. $20 for wearing AntiGraph 3. $1 per response
Ratcliff et al, 2014	To examine the interplay between sleep and cancer related symptoms during a cycle of CT.	Sample size: N=21 Cancer Type: Breast cancer Treatments: Neoadjuvant or Adjuvent CT Cancer Stage: I, II or III Age: Not specified Gender: 100% female Treatment trajectory: Active cancer treatment Country of origin: USA	Primary outcome: Sleep quality Secondary outcomes: Symptoms and mood	Device: Palm PC Application name: Casio E-100 Operation system: Windows CE PPC	Monitoring periods: 4 times per day Duration: 21 days Data sampling: Signal contingent Prompts frequency: 2 prompts Prompt interval: 5 mins Snooze option: Not specified	Participation rate: 57% Attrition: 1/21 Missing data: Not specified Incentive: Not specified
Rivera-Rivera et al, 2022	To evaluate the trajectory of distress, wellbeing, social support and social constraint over time in people with cancer.	Sample size: N= 48 Cancer Type: cervical or head/neck cancer Treatments: Surgery, radiation or both Cancer Stage: all stages Age: 56 years (SD 7.90) Gender: male 63% Treatment trajectory: Not specified Country of origin: USA	Primary outcome: Social support Secondary outcomes: Social constraint	Device: Proactive, phone-based interactive voice response (IVR) system, or paper questionnaire Application name: Not specified Operation system: Not specified	Monitoring periods: daily Duration: 30-days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 72% Attrition: Missing data: Not specified Incentive: $20 for completion of the baseline assessment and up to $80 for the daily assessments

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Schuler et al, 2023	To test wearable sensor (WS) to trigger ecological momentary assessments (EMAs) and electronic patient-reported outcomes in community palliative care with patient–caregiver dyads.	Sample size: N= 15 dyads (30 participants) Cancer Type: Not specified Treatments: Not specified Cancer Stage: Not specified Age: 59 years Gender: 80% female patients and 27% female caregivers Treatment trajectory: Palliative Country of origin: Australia	Primary outcome: Feasibility and acceptability of wearable sensor Secondary outcomes: Not specified	Device: Wearable Sensor (WS) Application name: vivosmart4 Operation system: Garmin, Olath Device: Smart phone – apps installed and configured Application name: "Garmin-Connect"and"mEMA" Operation system: Garmin, Olath	WS Monitoring periods: Continuous Duration: 5 weeks Data sampling: Continuous Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified Smartphone app Monitoring periods: Daily, weekly and triggered by a signal contingent Duration: 5 weeks Data sampling: Event contingent and signal contingent from data received from WS Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: Wearable sensor daytime data – 73% (patients (69%); caregivers (77%)) Daily EMA - 44% Weekly IPOS - 79%. Attrition: Missing data: Not specified Incentive: Not specified
Shiyko et al, 2019	To randomly sample mindfulness states in a sample of mindfulness-untrained individuals following hospital discharge.	Sample size: N=66 Cancer Type: Non-small cell lung cancer Treatments: Minimally invasive surgery via video-assisted thoracotomy (VATS lobectomy) OR Stand thoracotomy and lobectomy (THOR) Cancer Stage: I Age: 66.1 (SD 7.9) Gender: 61% female Treatment trajectory: Post-surgery Country of origin: USA	Primary outcome: Mindfulness Secondary outcomes: Not specified	Device: Portable Palm Pilot (PDA) Application name: Not specified Operation system: Not specified	Monitoring periods: 2 times per day Duration: 14 days Data sampling: Signal contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 61% Attrition: 25% Missing data: 39% Incentive: Not specified
Solk et al, 2019	The purpose of this study is to determine the feasibility and acceptability of EMA data collection via smartphone and accelerometers in breast cancer patients using chemotherapy	Sample size: N=68 Cancer Type: Breast cancer Treatments: Chemotherapy Cancer Stage: I, II or III Age: Not specified Gender: 100% Female Treatment trajectory: Active cancer treatment Country of origin: USA	Primary outcome: EMA data collection Secondary outcomes: Accelerometer	Device: Smartphone Application name: Web-based browser Operation system: Not specified Device: Accelerometer Application name: GT3X-BT Operation system: ActiGraph	Monitoring periods: 4 times per day Duration: 10 days Data sampling: Signal contingent Prompts frequency: 3 prompts Prompt interval: 15 mins Snooze option: Not specified	Participation rate: 86% (EMA); 82.3% (Accelerometer) Attrition: 5/68 Missing data: Not specified Incentive: Not specified
Steffen et al, 2018	To examine how daily hope, defined as goal-directed effort and planning to meet goals, and daily stigma were related to same- and next-day functioning in lung cancer patients receiving cancer treatment	Sample size: N= 50 Cancer Type: Lung cancer Treatments: Chemotherapy or Radiation Cancer Stage: IIIa- IV Age: Not specified Gender: 58% female Treatment trajectory: Active treatment Country of origin: Mexico	Primary outcome: Hope Secondary outcomes: Stigma	Device: online, paper, or via telephone – patient preference Application name: Not specified Operation system: Not specified	Monitoring periods: Daily Duration: 21 days Data sampling: interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 99.2% Attrition: Missing data: under 5% Incentive: $30 for initial questionnaire, $3 for each daily entry, $4 for each week they completed, and $6 for completing all 21 days. Paid in gift card

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Table 1 (*Continued*)

Study Characteristics Authors and Country	Aim	Participant Characteristics	EMA Data Collection Methods Outcomes	System Characteristics	EMA Schedule	Response-Related Results
Stephenson et al, 2018	To examine between-person and within-person associations between pain intensity and analgesia use in breast cancer patients	Sample size: N=53 Cancer Type: Breast cancer Treatments: Chemotherapy, radiation and hormone therapy Cancer Stage: I, II, III and IV Age: 49.38 years (SD 10.76) Gender: 100% Female Treatment trajectory: Active cancer treatment Country of origin: Canada	Primary outcome: Pain intensity Secondary outcomes: Analgesia use	Device: Electronic diary Application name: Palm Tungsten E Operation system: Not specified	Monitoring periods: 6 times per day Duration: 14 days Data sampling: Signal contingent Prompts frequency: 3 prompts Prompt interval: 5 mins Snooze option: Not specified	Participation rate: 70% Attrition: 5/68 Missing data: Not specified Incentive: up to $80 based on percentage of completed assessments
Vandenberg et al, 2022	To evaluate the feasibility and descriptive quality of capturing PROMs through daily micro surveys using a smartphone.	Sample size: N=95 Cancer Type: Breast, Skin/ Soft tissue/ Endocrine, and Abdominal Cancers Treatments: Not specified Cancer Stage: Not specified Age: 52.1 (SD 12.9) Gender: 66% Female Treatment trajectory: Perioperative Country of origin: USA	Primary outcome: Feasibility of daily micro surveys Secondary outcomes: HRQoL	Device: Smartphone Application name: Beiwe Operation system: Android or iOS	Monitoring periods: Daily micro surveys and 4 RAND short form-36 completed pre-op then 4 weeks, 12 weeks and 14 weeks post op Duration: Daily micro surveys completed preoperative to 24-weeks post op Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 34% daily micro surveys; 74% SF-36 Attrition: 4% Missing data: Not specified Incentive: No compensation
Vehling et al, 2018	To assess intraindividual changes in loss orientation and life engagement for people with advanced cancer	Sample size: N= 17 Cancer Type: Gastrointestinal, Genitourinary, breast, lung or other (not specified) Treatments: Surgery chemotherapy, radiation. Cancer Stage: IV Age: 61 years (SD not specified) Gender: 10/17 female Treatment trajectory: Palliative Country of origin: Germany	Primary outcome: Acceptability of daily assessments of death-related concerns Secondary outcomes: Loss orientation and life engagement	Device: Paper booklet Application name: N/A Operation system: N/A	Monitoring periods: Daily Duration: 7 days Data sampling: Interval contingent Prompts frequency: Not specified Prompt interval: Not specified Snooze option: Not specified	Participation rate: 46% participation rate, 97% diary completion rate Attrition: Not specified Missing data: Not specified Incentive: Not specified
Whitaker et al, 2022	To understand real-time relationships between physical activity and symptoms during chemotherapy using ecological momentary assessment.	Sample size: N=67 Cancer Type: Breast cancer Treatments: Chemotherapy Cancer Stage: I to III Age: 48.6 (SD 10.3) Gender: 100% Female Treatment trajectory: In treatment Country of origin: USA	Primary outcome: Physical activity Secondary outcomes: Symptoms	Device: ActiGraph Accelerometer Application name: wGT3X-BT Operation system: Actilife 6.13.3 AND Device: Smartphone Application name: Not specified Operation system: Not specified	Monitoring periods: 4 times per day Duration: 3 × 10 days Data sampling: Signal contingent Prompts frequency: Not specified Prompt interval: 15 mins prompts for 60 mins Snooze option: Not specified	Participation rate: Not specified Attrition: Not specified Missing data: Not specified Incentive: Not specified

Table 2
Results of Quality Assessment

Qualitative Study	Item number of check list						
	S1.	S2.	1.1.	1.2.	1.3.	1.4.	1.5.
Paterson et al, (2020)	Y	Y	Y	Y	Y	Y	Y

Item number check list key*: S1. Are there clear research questions, S2. Do the collected data allow to address the research questions, 1.1. Is the qualitative approach appropriate to answer the research question, 1.2. Are the qualitative data collection methods adequate to address the research question, 1.3. Are the findings adequately derived from the data, 1.4. Is the interpretation of results sufficiently substantiated by data, 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation.

Quantitative Descriptive Studies	Item number of check list						
	S1.	S2.	4.1.	4.2.	4.3.	4.4.	4.5.
Abraham et al, (2015)	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Aigner et al, (2016)	Y	Y	Y	U	Y	U	U
Aldaz et al, (2019)	Y	Y	Y	U	U	U	Y
Badr et al, (2006)	Y	Y	Y	Y	Y	Y	U
Badr et al, (2010)	Y	Y	Y	Y	Y	Y	Y
Basen-Enquist et al, (2013)	Y	Y	Y	Y	Y	Y	Y
Belcher et al, (2011)	Y	Y	Y	Y	Y	U	Y
Buck & Morley (2006)	Y	Y	Y	Y	Y	Y	Y
Curran et al, (2004)	Y	Y	Y	Y	Y	Y	Y
Escudero-Vilaplana et al, (2022)	U	U	Y	Y	U	Y	U
Glaus et al, (1993)	Y	Y	Y	Y	Y	U	Y
Grassi et al, (2015)	Y	Y	Y	Y	Y	Y	Y
Hacker et al, (2006)	Y	Y	Y	Y	Y	Y	Y
Hacker et al, (2007)	Y	Y	Y	Y	Y	Y	Y
Hacker et al, (2017)	Y	Y	Y	Y	Y	U	Y
Hanisch et al, (2009)	Y	Y	Y	Y	Y	Y	Y
Harnes et al, (2021)	U	Y	N	U	Y	N	U
Harper et al, (2012)	Y	U	Y	Y	U	U	U
Heathcote et al, (2022)	Y	Y	Y	Y	Y	U	Y
Kim et al, (2016)	Y	U	U	Y	Y	Y	Y
Langer et al, (2018)	Y	Y	Y	Y	Y	Y	U
Müller et al, (2019)	Y	Y	Y	Y	Y	Y	Y
Otto et al, (2015)	Y	Y	Y	Y	U	U	Y
Paterson et al, (2019)	Y	Y	Y	Y	Y	Y	Y
Paxton et al, (2022)	Y	U	Y	U	Y	U	Y
Phillips et al, 2020	Y	Y	Y	U	Y	Y	Y
Pinto et al, (2021)	Y	Y	Y	Y	Y	Y	U
Ratcliff et al, (2014)	Y	Y	Y	Y	Y	Y	Y
Rivera-Rivera et al, (2022)	Y	Y	Y	Y	Y	Y	Y
Shiyko et al, (2019)	U	Y	Y	Y	U	U	U
Solk et al, (2019)	Y	Y	Y	Y	Y	Y	U
Steffen et al, (2018)	Y	Y	Y	Y	Y	Y	Y
Stevenson et al, (2018)	Y	U	U	Y	U	Y	Y
Van den Berg et al, (2022)	Y	U	U	Y	Y	U	Y
Whitaker et al, (2022)	Y	Y	Y	Y	Y	Y	Y

Item number check list key*: S1. Are there clear research questions, S2. Do the collected data allow to address the research questions, 4.1. Is the sampling strategy relevant to address the research question, 4.2. Is the sample representative of the target population, 4.3. Are the measurements appropriate, 4.4. Is the risk of non-response bias low, 4.5. Is the statistical analysis appropriate to answer the research question

Mixed Methods	Item number of check list						
	S1.	S2.	5.1.	5.2.	5.3.	5.4.	5.5.
Ainsworth et al, (2018)	Y	Y	Y	Y	Y	Y	Y
Auster–Gussman et al, (2022)	Y	Y	Y	Y	Y	Y	Y
Campbell et al, (2022)	Y	Y	Y	Y	Y	Y	Y
Schuler et al, (2023)	Y	Y	Y	Y	Y	Y	Y
Vehling et al, (2018)	Y	Y	Y	Y	Y	Y	Y

Item number check list key*: S1. Are there clear research questions, S2. Do the collected data allow to address the research questions, 5.1. Is there an adequate rationale for using a mixed methods design to address the research question, 5.2. Are the different components of the study effectively integrated to answer the research question, 5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted, 5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed, 5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved

*Three levels of assessment quality scores
Yes (Y)
Unclear (U)
No (N)

symptoms,[29-39] pattern of fatigue following and during cancer treatment,[23,40-45] quality of life,[46-48] mindfulness,[49] pain management,[50] hot flushes,[51] "scanxiety" in young people affected by cancer,[52] depression screening,[53] spousal communication and satisfaction,[54-58] hope and stigma,[38] assessment of self-management behaviors,[57,59] and explored participants experiences of taking part in an EMA study.[15]

Sample Characteristics

As the aims of the studies were diverse, so were the included cancer populations. Most of the studies included participants affected by breast cancer,[21,24-28,30,35,40,43,50,53,56,58] breast and ovarian,[29] endometrial,[22] colorectal,[57] mixed cancer groups,[31-34,36,39,44,46-48,54]

haematological,[41,42,45] prostate,[15,51,57] and lung,[38,49] and four studies did not report cancer types.[23,37,52,59] Participants completed the EMA study before cancer treatment,[47] during active cancer treatment,[23,25,26,28-30,33-35,38,44,48,50-52,54] post treatment,[31,32,40,41,43,49,56] and palliative care,[37,39,59] and a considerable number of studies did not report on the treatment trajectory.[15,21,22,24,36,39,42,46,53,55,57] The majority of the studies were biased in favor of females with the exception of several studies with mixed gender samples,[15,23,26,31,32,34,41,44-46,49,54,57,59] and two studies did not report on gender.[52,53] All of the studies included adults with cancer with the exception of one study that included children and young people affected by cancer.[52] The samples across the studies also included couple dyads.[37,54-56,58,60]

EMA Sampling Approach

The EMA sampling protocols included interval contingent,[22,23,27,30-34,36,38-40,42,44,45,47,48,51,53,56,58,59] event contingent,[21,46] and signal contingent.[15,24-26,28,29,35,37,41,43,49,52,55,57] The EMA sampling protocol durations lasted from 3[42] to 4,[51] 5,[21,34] 6,[40] 7,[24,29,32,39,41,44,56,58] 10,[23,25-27,45,59] 11,[52] 14,[30,31,43,49,50,53-55,57] 21,[28,38] and 31 days,[15,36,37,48,57] including much longer protocols capturing real-time data up to 4–6 months.[22,33,46,47] Most of the studies used either smartphones, handheld computers, or web-based browsers, and some studies used paper-based diaries.[23,32-34,39,40,44,51,59] The paper-based studies.[23,32-34,39,40,44,51,59] lacked a date and time stamp and, consequently, participants could have forwarded or back-filled their diary answers. However, most EMA studies in cancer are now time-stamping assessment of entries, which is the gold standard. Unfortunately, most of the studies did not report on the software application used to collect real-time data.

EMA Response Rates

Information on the participant response rates were reported in most included studies. Overall, the response rate to daily EMA questionnaires were moderate to high: 50–69%,[28,49,55] 70–79%,[24,31,35-37,47,50,56] <80–89%,[15,23,25,27,29,33,34,42,45,46,48,51,52,54,57,58] and <90–100%,[21,22,30,32,38,39,43,53,59] and four studies did not report this information.[26,40,41,44,57] It is also important to point out that some of the studies[22,24,32,33,36,40,50,52,54,55] used monetary compensation for participants to complete their agreed EMA data collection intervals, which may have introduced bias in response rates.

EMA Outcome Measures in Cancer

A detailed overview of the constructs measured, individual question items, and rating scales are detailed in Supplementary Table 3. It was important to capture the EMA outcome items for future EMA studies in cancer and making these accessible to cancer care researchers. What is clearly apparent, however, within existing EMA studies in cancer is that there is significant heterogeneity and lack of consistency, and this shortcoming does warrant attention to develop core outcome sets to be used in EMA cancer research. Similar constructs were captured across the studies to illustrate this point: distress,[32] mood,[24-29,31,32,35,40,43,52,53,55] fatigue,[23,25,26,29,40-45,57] pain[23-26,29,30,35,40,50,55,57] (with the exception of two studies[25,26] that assessed pain using the same item and scale), illness uncertainty,[32] coping,[32] self-efficacy,[22,25,27,43] exercise,[22,23,25-27,35,40-42,46] self-management behaviors,[52,57,59] anxiety,[26,53] and relationship intimacy,[56] but most studies did not measured these constructs in the same way and in the main also did not report on content validity or reliability.

Implications of Findings for Supportive Care

Evidence across the studies have demonstrated that people affected by cancer have shown acceptability towards mobile real-time measurements[25,30,46] including children and young people,[52] patients and partners[54,56,58] which has the potential for informing future interventions.[21] Across the exercise studies there were some nuanced findings. Firstly, within the context of exercise in cancer a causal relationship was observed between morning self-efficacy and exercise minutes, which suggests that real-time interventions to target daily variation in self-efficacy may benefit exercise adherence.[22,27] There was an inverse relationship between real-time reports of fatigue and physical activity levels.[41-43] It would be important to consider fatigue and self-efficacy on exercise adherence in development of future interventions.[61]

In people affected by cancer fatigue and pain have been shown to be significantly associated with greater negative mood in real time[29,55] and remained problematic 18 months after treatment was completed.[40] From a clinical perspective, this observation underscores the importance of timely identification and routine screening for mood disorders[32,53] in patients. This finding was particularly important for children and young people affected by “scanxiety” who were found to report significantly more daily fear of cancer recurrence and negative mood several days before a scan compared to the days after surveillance scans, and support should be provided in this context.[52]

Many patients affected by various cancers experienced distressing and daily fluctuations in symptoms,[23,30-35,37,38,44,48,50,51,55,57] on average four symptoms daily,[23] a range of unmet supportive care needs,[15] sadness, anxiety and stress reported on a daily basis,[24,36] and poor sleep.[28] Patients valued completing daily real-time reporting and some participants expressed that they developed an increased awareness and understanding of their condition by participating in the EMA.[15] Only one study explored[15] experiences of men affected by prostate cancer participating in an EMA study, therefore, knowledge about the methodological complexities which may, or may not exist, for EMA cancer research remains unknown.

Discussion

This systematic review set out to critically synthesize the current state of the evidence using EMA in cancer. What is apparent is the significant heterogeneity in methods and widely varying approaches to design and self-report measurements. With 42 studies being included it is apparent that this approach is increasingly being used and is appealing to researchers given its documented advantages. EMA in cancer care research can be superior in comparison to existing retrospective PROMs such as capturing in real-time symptom burden and distress, impacts on survivorship and unmet supportive care needs, yet to be identified using EMA. This review has also shown in the context of cancer research that little if any consideration has been given to the validity and reliability of the EMA PROMs used to date. To advance the scientific field of EMA in cancer addressing this gap would be the first central step. This review specifically captured all self-reported items across all the studies in this review to advance this first important step. Strikingly while similar constructs have been measured across many different EMA cancer studies, researchers have used widely different items and response anchors. It was also observed that previous researchers have developed their EMA self-report items from existing standardized questionnaires. One approach to measuring an EMA item construct based from an existing standardized PROMs, is for the EMA questionnaire item to adopt the questionnaire item which had the highest factor loading[2] for that particular construct. However, items from existing questionnaires are not automatically valid in EMA and therefore, researchers must focus their efforts on standardizing valid and reliable questionnaires for use in EMA cancer studies. One approach might be to adopt the COSMIN guideline,[20] which was used as part of this review to assess existing EMA PROMs. However, this guideline might offer a practical step in the right direction for future EMA

studies in cancer care research. In the development of EMA questionnaires, it is acknowledged that there is a fine balance between burden on participants so generally the questionnaires are short in length which can create further challenges in the development of EMA questionnaires. A further important methodological consideration to advance the field is for cancer researchers to adopt the CREMAS guideline[17] to standardize the reporting of future studies[17] to enhance the comparability, reproducibility, and interpretation of findings.

The adoption and growing focus of EMA in cancer has the powerful potential to provide rich and valuable new insights for implications for survivorship care and identify solutions to address unmet supportive care needs in real time.[14] This review identified some real-time insights with implications for survivorship. However, given that the focus of the studies was so broad in this review not all studies had the focus on implications for optimizing survivorship for people affected by cancer, therefore the full potential of EMA in cancer care is not yet fully realized. For example, EMA methods could be embedded as part of a supportive care clinical randomised trial to optimize survivorship providing real-time assessments of the intervention and linking people's cognitions, behaviors, and feelings simultaneously.

Strengths and Limitations

To the best of our knowledge, this is the first comprehensive systematic review to describe the evidence-base for EMA in cancer research. Clearly, researchers will need to take careful considerations to design decisions in EMA studies in the future, however this review has provided a valuable first step to advance the field. There were no language limiters or date limited set in this review to ensure it captured all EMA studies in cancer. The database searches were conducted by and expert systematic review librarian to increase the inclusiveness, sensitivity, and specificity of the searches. This review also followed a rigorous process throughout all stages and was conducted independently by two reviewers. This review was conducted in Covidence Systematic review software and due to the limitation of this software the authors were unable to provide the full reference list of the six articles excluded articles at the full text review as a supplementary file.

Implications for Cancer Survivors

People affected by cancer found taking part in EMA studies to be acceptable and some reported benefit from the experience in taking part. However, researchers must engage with cancer survivors in the development and co-design of future EMA PROM items and questionnaires.

Conclusion

There is significant heterogeneity in methods and widely varying approaches to design and self-report measurements in EMA cancer research. While EMA in cancer research holds significant promise to advance cancer care research into the future by increasing ecological validity, reducing retrospective bias, and captures the unique idiographic within-person change over time, in real-time, further research is needed to develop standardized EMA self-report questionnaires. Capturing real-time assessments over-time can leverage the potential to understand patients' quality of life, unmet supportive care needs while simultaneously linking affect, thoughts, and behaviors in naturalistic settings.

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Armitage: Screening, Data extraction, Reviewing & Editing

Turner: Methodology, Data validation, Reviewing & Editing

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.soncn.2023.151514.

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Supplementary Table 1. Record of database searches

Five databases APA PsycINFO, CINAHL, Medline, (all via EBSCOhost), Scopus, Web of Science Core Collection, and one trial register, Cochrane Central Register of Controlled Trials, were searched on 9 June 2023 to identify relevant studies. No limiters were placed on any of the searches. Searches returned a total of 506 results. Search terms and number of results by database/register:

APA PsycINFO (58)

(("ecological momentary assessment*" OR EMA OR “ambulatory assessment*” OR “daily diary” OR “diary assessment*” OR “experience sampling method*” OR “event sampling” OR “intensive longitudinal”) AND (((electronic N6 (device* OR diar* OR self-report*)) OR e-PREMs OR e-PROMs OR (mobile N6 (app* OR device* OR phone* OR technolog*)) OR "patient reported" OR PREMs OR PROMs OR real-time* OR (smart N6 (app* OR device* OR phone* OR technolog*)))) AND (cancer* OR oncolog* OR neoplasm*))

CINAHL (27)

(("ecological momentary assessment*" OR EMA OR “ambulatory assessment*” OR “daily diary” OR “diary assessment*” OR “experience sampling method*” OR “event sampling” OR “intensive longitudinal”) AND (((electronic N6 (device* OR diar* OR self-report*)) OR e-PREMs OR e-PROMs OR (mobile N6 (app* OR device* OR phone* OR technolog*)) OR "patient reported" OR PREMs OR PROMs OR real-time* OR (smart N6 (app* OR device* OR phone* OR technolog*)) OR (MH "Cellular Phone+") OR (MH "Mobile Applications") OR (MH "Patient-Reported Outcomes+"))) AND (cancer* OR oncolog* OR neoplasm*))

Cochrane Central Register of Controlled Trials (34)

Search #	Concept	Search Terms	Results
#1		"ecological momentary assessment*" OR EMA OR “ambulatory assessment*” OR “daily diary” OR “diary assessment*” OR “experience sampling method*” OR “event sampling” OR “intensive longitudinal”	3,886
#2		MeSH descriptor: [Ecological Momentary Assessment] explode all trees	75
#3	Ecological momentary assessment	#1 OR #2	2,107
#4		((electronic NEAR/6 (device* OR diar* OR self-report*)) OR e-PREMs OR e-PROMs OR (mobile NEAR/6 (app* OR device* OR phone* OR technolog*)) OR "patient reported" OR PREMs OR PROMs OR real-time* OR (smart NEAR/6 (app* OR device* OR phone* OR technolog*)))	43,266
#5		MeSH descriptor: [Cell Phone] explode all trees	2,397
#6		MeSH descriptor: [Mobile Applications] explode all trees	1,144
#7		MeSH descriptor: [Patient Reported Outcome Measures] explode all trees	1,014
#8		MeSH descriptor: [Smartphone] explode all trees	688
#9	Data collection	#4 OR #5 OR #6 OR #7 OR #8	44,361
#10	Cancer patients	cancer* OR oncolog* OR neoplasm*	239,577

#11		#3 AND #9 AND #10	34

MEDLINE (168)

(("ecological momentary assessment*" OR EMA OR (MH "Ecological Momentary Assessment") OR “ambulatory assessment*” OR “daily diary” OR “diary assessment*” OR “experience sampling method*” OR “event sampling” OR “intensive longitudinal”) AND ((((electronic N6 (device* OR diar* OR self-report*)) OR e-PREMs OR e-PROMs OR (mobile N6 (app* OR device* OR phone* OR technolog*)) OR "patient reported" OR PREMs OR PROMs OR real-time* OR (smart N6 (app* OR device* OR phone* OR technolog*)) OR (MH "Cell Phone+") OR (MH "Mobile Applications") OR (MH "Patient Reported Outcome Measures+") OR (MH "Smartphone")))) AND (cancer* OR oncolog* OR neoplasm*))

Scopus (116)

TITLE-ABS-KEY (("ecological momentary assessment*" OR EMA OR “ambulatory assessment*” OR “daily diary” OR “diary assessment*” OR “experience sampling method*” OR “event sampling” OR “intensive longitudinal”) AND (((electronic W/6 (device* OR diar* OR self-report*)) OR e-PREMs OR e-PROMs OR (mobile W/6 (app* OR device* OR phone* OR technolog*)) OR "patient reported" OR PREMs OR PROMs OR real-time* OR (smart W/6 (app* OR device* OR phone* OR technolog*)))) AND (cancer* OR oncolog* OR neoplasm*))

Web of Science Core Collection (103)

TS=(("ecological momentary assessment*" OR EMA OR “ambulatory assessment*” OR “daily diary” OR “diary assessment*” OR “experience sampling method*” OR “event sampling” OR “intensive longitudinal”) AND (((electronic NEAR/6 (device* OR diar* OR self-report*)) OR e-PREMs OR e-PROMs OR (mobile NEAR/6 (app* OR device* OR phone* OR technolog*)) OR "patient reported" OR PREMs OR PROMs OR real-time* OR (smart NEAR/6 (app* OR device* OR phone* OR technolog*)) OR (MH "Cellular Phone+") OR (MH "Mobile Applications") OR (MH "Patient-Reported Outcomes+"))) AND (cancer* OR oncolog* OR neoplasm*))

Supplementary Table 2. Assessment EMA PROM

Authors	Content validity	Yes	No	Unclear
Abraham et al (2015)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	-	√
	4. Internal consistency	-	-	√
	5. Cross-cultural validity\measurement invariance	√	-	
	Remaining measurement properties			
	6. Reliability	-	-	√
	7. Measurement error	-	-	√
	8. Criterion validity	-	-	√
	9. Hypotheses testing for construct validity	√		
	10. Responsiveness	√		
Aigner et al. 2016	1. PROM development reported	-	√	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-

	Remaining measurement properties 6. Reliability 7. Measurement error 8. Criterion validity 9. Hypotheses testing for construct validity 10. Responsiveness	 - - - - -	 **√** **√** **√** **√** **√**	 - - - - -
Ainsworth et al. (2018)	1. PROM development reported 2. Content validity **Internal structure** 3. Structural validity 4. Internal consistency 5. Cross-cultural validity\measurement invariance **Remaining measurement properties** 6. Reliability 7. Measurement error 8. Criterion validity 9. Hypotheses testing for construct validity 10. Responsiveness	**√** - - - - - - - - - -	- **√** **√** **√** **√** **√** **√** **√** **√**	- - - - - - - - -

Aldaz et al. (2019)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	-	√
	4. Internal consistency	√	-	-
	5. Cross-cultural validity\measurement invariance	-	-	√
	Remaining measurement properties			
	6. Reliability	√	-	-
	7. Measurement error	-	-	√
	8. Criterion validity	-	-	√
	9. Hypotheses testing for construct validity	-	-	√
	10. Responsiveness	-	-	√
Auster-Gussman et al. 2022	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-

	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Badr et al. (2006)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Badr et al. (2010)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			

	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Basen-Enquist et al. (2013)	1. PROM development reported	√	-	-
	2. Content validity	-	-	√
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-

	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Belcher et al. (2011)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	√	-	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Buck et al. (2006)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency		√	-

	5. Cross-cultural validity\measurement invariance **Remaining measurement properties**	- -	√	-
	6. Reliability	√	-	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Campbell et al. (2022)	1. PROM development reported	√	-	-
	2. Content validity **Internal structure**	-	√	-
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance **Remaining measurement properties**	-	√	-
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-

Curran et al. (2004)	1. PROM development reported	√	-	-
	2. Content validity	-	-	√
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-

Escudero-Vilaplana et al. (2022)	1. PROM development reported	**√**	**-**	**-**
	2. Content validity	**-**	**-**	**√**
	Internal structure			
	3. Structural validity	**√**	**-**	**-**
	4. Internal consistency	**-**	**√**	**-**
	5. Cross-cultural validity\measurement invariance	**-**	**√**	**-**
	Remaining measurement properties			
	6. Reliability	**-**	**√**	**-**
	7. Measurement error	**-**	**√**	**-**
	8. Criterion validity	**-**	**√**	**-**
	9. Hypotheses testing for construct validity	**-**	**√**	**-**
	10. Responsiveness	**-**	**√**	**-**

Glaus et al. 1993	1. PROM development reported	√	-	-
	2. Content validity	-	-	√
	Internal structure			
	3. Structural validity	√	-	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-

Grassi et al. 2015	1. PROM development reported	√	-	-
	2. Content validity	-	-	√
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Hacker et al. (2017)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	-	√

	Remaining measurement properties 6. Reliability 7. Measurement error 8. Criterion validity 9. Hypotheses testing for construct validity 10. Responsiveness	 - - - - -	 **√** **√** **√** **√** **√**	 - - - - -
Hacker et al. (2006)	1. PROM development reported 2. Content validity **Internal structure** 3. Structural validity 4. Internal consistency 5. Cross-cultural validity\measurement invariance **Remaining measurement properties** 6. Reliability 7. Measurement error 8. Criterion validity 9. Hypotheses testing for construct validity 10. Responsiveness	**√** - - - - - - - - -	- - **√** **√** **√** **√** **√** **√** **√** **√**	- **√** - - - - - - - -

Hacker et al. (2007)	1. PROM development reported	**√**	-	-
	2. Content validity	-	-	**√**
	Internal structure			
	3. Structural validity	-	**√**	-
	4. Internal consistency	-	**√**	-
	5. Cross-cultural validity\measurement invariance	-	**√**	-
	Remaining measurement properties			
	6. Reliability	-	**√**	-
	7. Measurement error	-	**√**	-
	8. Criterion validity	-	**√**	-
	9. Hypotheses testing for construct validity	-	**√**	-
	10. Responsiveness	-	**√**	-
Hanisch et al. (2009)	1. PROM development reported	**√**	-	-
	2. Content validity	-	-	**√**
	Internal structure			
	3. Structural validity	-	**√**	-
	4. Internal consistency	-	**√**	-
	5. Cross-cultural validity\measurement invariance	-	**√**	-
	Remaining measurement properties			
	6. Reliability	-	**√**	-

	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Harper et al. (2012)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	√	-	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Heathcote et al. (2007)	1. PROM development reported	√	-	-
	2. Content validity	-	-	√

	Internal structure 3. Structural validity 4. Internal consistency 5. Cross-cultural validity\measurement invariance **Remaining measurement properties** 6. Reliability 7. Measurement error 8. Criterion validity 9. Hypotheses testing for construct validity 10. Responsiveness	- - - - - - - -	√ √ √ √ √ √ √ √	- - - - - - - -
Kim et al. (2016)	1. PROM development reported 2. Content validity **Internal structure** 3. Structural validity 4. Internal consistency 5. Cross-cultural validity\measurement invariance **Remaining measurement properties** 6. Reliability 7. Measurement error	√ - - - - - -	- √ √ √ √ √ √	- - - - - - -

	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Langer et al. (2018)	1. PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Müller et al. 2019	1. PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-

	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Otto et al. (2015)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	√	-	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-

	10. Responsiveness	-	**√**	-
Paterson (2019)	1. PROM development reported	**√**	-	-
	2. Content validity	-	-	**√**
	Internal structure			
	3. Structural validity	-	**√**	-
	4. Internal consistency	-	**√**	-
	5. Cross-cultural validity\measurement invariance	-	**√**	-
	Remaining measurement properties			
	6. Reliability	-	**√**	-
	7. Measurement error	-	**√**	-
	8. Criterion validity	-	**√**	-
	9. Hypotheses testing for construct validity	-	**√**	-
	10. Responsiveness	-	**√**	-
Paterson et al. (2020)	1. PROM development reported	-	**√**	-
	2. Content validity	-	**N/A**	-
	Internal structure	-	**N/A**	-
	3. Structural validity	-	**N/A**	-

	4. Internal consistency			
			N/A	-
	5. Cross-cultural validity\measurement invariance	-		
			N/A	-
	Remaining measurement properties	-		
	6. Reliability		**N/A**	-
		-		
	7. Measurement error		**N/A**	-
		-		
	8. Criterion validity		**N/A**	-
		-		
	9. Hypotheses testing for construct validity		**N/A**	-
	10. Responsiveness			
Paxton et al. (2022)	1. PROM development reported	**√**	-	-
	2. Content validity	**√**	-	-
	Internal structure			-
	3. Structural validity	-	**√**	
				-
	4. Internal consistency	-	**√**	
				-
	5. Cross-cultural validity\measurement invariance	-	**√**	
	Remaining measurement properties			
	6. Reliability	**√**	-	-
	7. Measurement error	-	**√**	-
	8. Criterion validity	-	**√**	-
	9. Hypotheses testing for construct validity	-	**√**	-
	10. Responsiveness	-	**√**	-

Phillips et al. (2020)	1. PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Pinto et al. (2021)	1. PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			

	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Ratcliff et al. (2014)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure	-	√	-
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance			
	Remaining measurement properties	-	√	-
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness			
Rivera-Rivera et al. (2021)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-

	Internal structure 3. Structural validity 4. Internal consistency 5. Cross-cultural validity\measurement invariance **Remaining measurement properties** 6. Reliability 7. Measurement error 8. Criterion validity 9. Hypotheses testing for construct validity 10. Responsiveness	- - - - - - - -	√ √ √ √ √ √ √ √	- - - - - - - -
Schuler et al. (2023)	1. PROM development reported 2. Content validity **Internal structure** 3. Structural validity 4. Internal consistency 5. Cross-cultural validity\measurement invariance **Remaining measurement properties** 6. Reliability 7. Measurement error 8. Criterion validity	√ - - - - - - -	- - √ √ √ √ √ √	- √ - - - - - -

	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Shiyko et al (2019)	1. PROM development reported	√	-	-
	2. Content validity	-	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Solk et al. (2019)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure	-		-
	3. Structural validity	-	√	-
	4. Internal consistency		√	

	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Teffen et al. 2018)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			-
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	
	Remaining measurement properties			
	6. Reliability	√	-	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-

Stevenson et al. (2018)	1. PROM development reported	√	-	-
	2. Content validity	√	-	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Van den Berg et al. (2022)	1. PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-

	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Vehling et al. (2018)	1. PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-
	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-
Whitaker et al. (2022)	PROM development reported	√	-	-
	2. Content validity	-	√	-
	Internal structure			
	3. Structural validity	-	√	-

	4. Internal consistency	-	√	-
	5. Cross-cultural validity\measurement invariance	-	√	-
	Remaining measurement properties			
	6. Reliability	-	√	-
	7. Measurement error	-	√	-
	8. Criterion validity	-	√	-
	9. Hypotheses testing for construct validity	-	√	-
	10. Responsiveness	-	√	-

Definition of terms: Content validity (The degree to which the content of a PROM is an adequate reflection of the construct to be measured); Structural validity (The degree to which the scores of a PROM are adequate reflection of the dimensionality of the construct to be measured); Internal consistency (The degree of the interrelatedness among the items); Cross-cultural validity\measurement invariance (The degree to which the performance of the items on a translated or culturally adapted PROM are an adequate reflection of the performance of the items of the original version of the PROM); Reliability (The proportion of the total variance in the measurements differences between patients); Measurement error (The systematic and random error of a patient's score that is not attributed to true changes in the construct to be measured); Criterion validity (The degree to which the scores of a PROM are an adequate reflection of a 'gold standard'); Hypotheses testing for construct validity (The degree to which the scores of a PROM are consistent with hypotheses (for instance with regard to internal relationships, relationships to scores of other instruments, or differences between relevant groups) based on the assumption that the PROM validly measures the construct to be measured); Responsiveness (The ability of a PROM to detect change over time in the construct to be measured).

Supplementary Table 3. EMA Outcome measures and question items

Study	EMA Outcome items
Abraham et al. 2015	In the past 24 hours, did you have breast pain? Responses: Yes, No Select the number that best describes your worst breast pain in the past 24 hours. Responses: 1 = Very mild breast pain, 10 = Worst possible breast pain In the past 24 hours, did your breasts feel swollen? Responses: 0 = Not at all, 10 = Extremely In the past 24 hours, did your breast feel sensitive to contact? Responses: 0 = Not at all, 10 = Extremely
Aigner et al. 2016	To assess pain, participants were asked to report the intensity of pain they experienced throughout the day on a 5-point rating scale, from 1, "No pain," to 5, "Pain as bad as you can imagine." To assess sad mood, anxious mood, and urge, smokers were asked to respond to two items summarizing how much they felt of each throughout the day ("I felt sad," "I felt anxious," "I have had an urge to smoke") on a 5-point rating scale with the following anchors: "Strongly disagree," "Disagree," "Neutral," "Agree," and "Strongly agree." Cigarette use was assessed as the number of cigarettes smoked per day, using the following scale: "0" representing no cigarettes, "1" for one cigarette, "2" for two cigarettes, "3" for three cigarettes, "4" for four cigarettes, "5" for 5–10 cigarettes, "6" for 11–20 cigarettes, and "7" for more than 20 cigarettes. Lastly, we assessed daily usage of over the counter and prescription pain medication by asking participants to indicate how many pills of each they took each day (eg, "Overall, how many prescription pills have you taken today?").
Aldaz et al. 2019	The distress thermometer consisted of a visual analogue distress thermometer (range 0 10, anchored at 0' no distress ' to 10' extreme distress'). Participants rated their overall treatment-related daily distress using this thermometer. Daily psychological well-being: The Flourishing Scale is an 8-item measure of socio emotional well-being that measures wellness in relationships, self-esteem, purpose and meaning in life (e.g. 'I am optimistic about my future'; 'I am interested in my daily activities'). Daily illness uncertainty: Mishel's Uncertainty in Illness Scale–Community Form (MUIS-C): five items from MUIS-C for use in the daily diary. Items were selected based on their usability in a daily context. The wording of the five items was adapted to make it clear participants were asked to rate how they felt that day. The five items whereas follows: (i)'Today I am unsure if my health is getting better or worse'; (ii)'Today I have a lot of questions without answers'; (iii)'It is difficult to know today if the treatments or medications I am getting are helping'; (iv) 'Because of the unpredictability of cancer today, I cannot plan for the future' and; (v) 'I'm certain today they will not find anything else wrong with me in the future'. Participants rated how they felt 'today 'on a scale ranging from 1'strongly disagree' to 5 'strongly agree'. Daily Experiential Avoidance (EA): EA of illness uncertainty-related thoughts and/or emotions four items measuring their efforts to control or avoid unpleasant thoughts and/ or emotions related to illness uncertainty (e.g. 'How upset and bothered were you about any uncertainty-related feelings or thoughts today?').Participants answered each question using a five-point scale ranging from 1'very slightly or not at all 'to 5 'extremely'.
Ainsworth et al., 2018	Response anchors: 5-point Likert-scale, yes or no, and open-ended items

	Self-administered 16-item questionnaire assessed functionality and participant experiences with the time use of Life in a Day app. Statements such as "Learning to use the Life in a Day app was easy," Navigating the Life in a Day app was clear and understandable," and "I enjoyed using the Life in a Day app." When logging activities during this period, participants were asked to select up to 3 categories (eg, walking, errand, or appointment) to identify the purpose of the activity. No further details reported.
Auster-Gussman et al. 2022	<u>Same day:</u> Self-efficacy: I am confident I can replace at least 60 min of sitting and/or lying down with standing or light intensity activities today (i.e. House hold chores, light walking, etc.). 0% to 100% with 10-point increments. Physical outcome expectations: Exercise will improve my overall body functioning today. 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). Psychological outcome expectations: Exercise will improve my psychological state today. 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). Day goal setting: I have plans to engage in some form of exercise for at least 30 min today. 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). <u>Next day:</u> Self-efficacy: I am confident I can exercise for at least 30 min tomorrow. 0% to 100% with 10-point increments. Physical outcome expectations: Exercise will improve my overall body functioning tomorrow. 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). Psychological outcome expectations: Exercise will improve my psychological state tomorrow. 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). Day goal setting: I have plans to engage in some form of exercise for at least 30 min tomorrow. 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree).
Badr et al, 2006	<u>Mood:</u> 16 mood adjectives (examples of questions not reported). 5-point Likert-type scale ranging from 1 (not at all) to 5 (extremely) <u>Fatigue</u>: 11-point Likert-type scale from 0 (no fatigue) to 10 (worst fatigue imaginable) using a single item from the Brief Fatigue Inventory <u>Pain:</u> 11-point Likert type scale from 0 (no pain) to 10 (worst pain imaginable) using one item from the Brief Pain Inventory No further details reported.
Badr et al. (2010)	<u>Mood:</u> 16 mood adjectives (examples of questions not reported). 5-point Likert-type scale ranging from 1 (not at all) to 5 (extremely) <u>Fatigue</u>: 11-point Likert-type scale from 0 (no fatigue) to 10 (worst fatigue imaginable) using a single item from the Brief Fatigue Inventory

	Pain: 11-point Likert type scale from 0 (no pain) to 10 (worst pain imaginable) using one item from the Brief Pain Inventory Relationship interference: ''My partner's cancer interfered with the quality of time we spent together today, "on a Likert-type scale ranging from 1 (not at all) to 4 (very much). Received emotional and physical support: ''Today my partner was attentive to my emotional needs" and ''Today my partner was attentive to my physical needs," on a Likert-type scale ranging from 1 (not at all) to 4 (very much). Provided emotional and physical support: ''Today I was attentive to my partner's emotional needs," and ''Today I was attentive to my partner's physical needs, "on a Likert-type scale ranging from 1 (not at all) to 4 (very much).
Basen-Engquist et al, 2013	Self-efficacy: "How confident are you that you will exercise today for the recommended amount of time?" The responses ranged from 1 (not at all confident) to 5 (extremely confident). Outcome expectations: seven positive items and three negative items "I will sleep more soundly tonight if I exercise today" and "Exercising today will be painful" scale range was 1 to 5; a higher score indicated greater positive or negative outcome expectations. Exercise duration: EMA questions answered at the time of exercise (real-time exercise minutes), EMA questions answered at the end of the day about exercise completed that day (night-time exercise diary minutes), and minutes of moderate or greater activity performed in bouts of at least 10 min as measured with the accelerometer.
Belcher et al. (2011)	Relationship intimacy: "What best describes the degree of happiness, all things considered, in your relationship?" and "How much intimacy/connectedness do you feel with your partner?" Participants indicated the extent to which they were experiencing these feelings "right now," just before retiring for the night. Ratings were made on a 7-point Likert-type scale, ranging from 1(not at all) to 7 (extremely). Negative affect: Daily NA was a composite of momentary ratings of seven affects (sad, angry, afraid, lonely, blue, scared, and frightened). Patients and spouses were asked to "tell us how much you feel this way at this moment" (1 very slightly/not at all; 3 somewhat; 5 a lot) Support provision: "Did you provide any help to your partner for a worry, problem or difficulty your partner had in the past 24 hours (yes/ no)?" Support receipt: "Did you receive any help from your partner for a worry, problem, or difficulty you had in the past 24 hours (yes/no)?"
Buck et al. 2006	Pain intensity: Pain intensity was measured using a 100mm VAS pain intensity rating scale, ranging from no pain to worst pain imaginable. Patients were asked to rate their average pain intensity over the specified session (morning, afternoon, or evening). The novelty of pain: Participants indicated whether the pain they experienced during each session was different to their usual pain. If their pain was different, they were asked to note whether it was more intense, less intense, in a different location, or was a different type of pain. A don't have usual pain option was available to participants who felt that they did not have what they would refer to as usual pain. The predictability of pain: Participants estimated whether their pain in the following session would be the same, higher, or lower in intensity than pain in the present session. This item allowed for the comparison of expected pain to actual pain, so that the effects of accurate, over-or under-predicted pain on pain, affect and coping could be investigated. Coping efficacy: 7-point scales ranging from 0 (no control/notable to decrease pain at all) to 6(complete control/able to decrease pain completely).

	The Positive and Negative Affect Schedule: The measure consists of two 10-item scales that measure positive and negative affect on 5-point numeric scales (1=very little or not at all, 5=extremely). Coping strategies: The statements include using a pain reduction effort, relaxation, redefinition, distraction, venting emotions, seeking emotional support, and seeking spiritual support. Three additional items were included in this study, which were ignoring pain (''I tried to ignore the pain''), focusing on pain (''I deliberately focused my attention on the pain''), and medication use (''I took my medication''). The characteristics of distraction strategies: To assess the motivational-affective characteristics of distracting tasks, participants were asked to rate on 5-point scales (1=not at all, 5=extremely) how interesting, pleasant, and important the distracting thought or activity was to them. Attention focusing strategies: A list of 6 items was included in the questionnaire where participants responded yes or no to whether they had deliberately focussed on specific aspects of their pain. These items assessed whether patients evaluated, worried about, or focused on either the somatic or emotional components of their pain when they focused on it. 1.I concentrated on what pain felt like. 2.I worried about the pain when I thought about it. 3.I concentrated on the pain to see if it was my normal or usual pain. 4.I concentrated on the pain so I could decide what I could do to control it. 5.I concentrated on my emotions, or how the pain made me feel, while I was in pain. 6.I concentrated on the pain and thought about what would happen to the pain–whether it would go away or get better or worse.
Campbell et al. (2022)	Symptoms: Participants rated the severity of 28 symptoms at their worst for the previous 24 hours, using a classic 0-to-10 response format, for symptoms (0, did not have; 10, as bad as I can imagine). No further details reported. Falls and "near falls": (losses of balance, slips, trips, and stumbles) during the same 24-hour period. No further details reported.
Curran et al, 2004	Current fatigue: 10-point Likert scales with one endpoint labelled no fatigue and the other endpoint labelled worst possible fatigue. Current pain: 10-point Likert scales with one endpoint labelled no pain and the other endpoint labelled worst possible pain. Current mood: PANAS consists of 20 mood adjectives and subjects rated each on a 5-point Likert scale with regard to how much each adjective described them at the moment. Endpoints were labelled very slightly or not at all to extremely. Daily activity level: A pedometer measuring daily distance walked.
Escudero-Vilaplana et al, 2022	Physical activity: these data are recorded in static and movement and different positions (orthostatic, sedentary, and decubitus). Performance status: ECOG-PS (yes no answers)
Glaus et al. (1993)	Fatigue: The instrument is scored by measuring the distance from the "I am not tired at all" to the opposite endpoint of the scale is "I am totally exhausted".

Grassi et al. (2015)	Nausea and Vomiting: the number of nausea and vomiting episodes, and the intensity of nausea on a 4-point Likert scale for nausea (0 = no nausea; 1 = mild nausea, i.e. presence of nausea but able to do all daily activities; 2 = moderate nausea, i.e. unable to do all daily activities; 3 = severe nausea, i.e. bedridden because of nausea). No further detailed reported.
Hacker et al, 2017	Real-time fatigue: measured with a 1-item, global fatigue intensity scale scores range from 0 (no fatigue) to 10 (worst) Physical activity: measured using a wrist-worn accelerometer
Hacker et al, 2007	Real-time fatigue: measured with a 1-item, global fatigue intensity scale scores range from 0 (no fatigue) to 10 (worst) Physical activity: measured using a wrist-worn accelerometer
Hacker et al. (2006)	Fatigue: patients rated the intensity of fatigue on a 1 (no fatigue) to 10 (worst fatigue) scale three times each day. Patients were instructed to enter the rating directly into the wrist actigraph via the subjective event marker on the face of the device.
Hanisch et al. (2009)	Hot flashes: Question items not reported.
Harper et al. (2012)	Quality of Life: QLQ-C30-Pall (Palliative Care): Questions 1-14 are rated using a 4-point scale (ranging from 0 = "not at all" to 3 = "very much"). A total patient-reported QOL score was calculated by summing daily item responses for each patient for these 14 questions; higher scores reflected more negative patient-reported QOL outcomes. No further details reported.
Harnas et al, 2021	EMA-survey consisted of 13 questions: Fatigue: "I felt tired"; Depression: "I felt sad" Fear of cancer recurrence: "I was worried or anxious about the recurrence of cancer"; Physical activity: "I was physically active"; Mental activity: "I was mentally active (for example by reading, concentrating, doing administrative work)" Social activity: "I was socially active (for example by speaking with other people or visiting someone)" Focus on fatigue: "I thought a lot about my fatigue" Catastrophizing: "The terrible feel of the fatigue kept me occupied" Powerlessness: "I felt powerless against my fatigue" Self-efficacy: "I am confident that I can do the things I want to do in the next few hours" Intrusion: "Things kept reminding me of cancer and/or cancer treatment" Avoidance: "I have avoided situations or things that made me think about cancer" Lack of social understanding: "I was faced with a lack of understanding regarding my fatigue".

	(Scores 0-100 high the score high rating)
Heathcote et al., 2022	Fear of cancer recurrence: two items adapted from the FCRI-SF that captured the number of times that participants thought about cancer that day and the level of worry about cancer that day. Stress: using items from the Perceived Stress Scale adapted for momentary use (no further details reported). Negative and Positive Affect (PA): five PA and 5 NA items adapted from the Positive and Negative Affect Scale (no further details reported). Bodily threat monitoring: one item that captured monitoring of bodily symptoms and one item that captured worry about bodily symptoms (no further details reported). Self-checking behaviours: one item on whether they physically examined themselves for signs of cancer that day (yes/no). Somatic symptoms: 14 items that were collated across several clinical symptom measures to capture symptom severity across a range of cancer-related and everyday symptoms (no further details reported). Social connectedness: two items that captured the number of social interactions and perceived level of social support (no further details reported). Objective physical activity: Screenshot of their ambulatory step count Score anchors not reported.
Kim et al, 2016	Sleep: single item sleep satisfaction level on a scale ranging from 0 (very good) to 10 (very bad). Mood: single item scale from 0 (none) to 7 (very severe) Anxiety: on a scale from 0 (none) to 10 (very severe)
Langer et al, 2018	Communication With Partner: "To what extent did you… Express your feelings during this conversation? Hold back from expressing your feelings? Support your partner? Criticize your partner?" "To what extent did you feel that your partner… Expressed his/her feelings? Supported you? Criticized you?" (1 = not at all; 3 = somewhat; 5 = extremely)
Müller et al. 2019	Pain Catastrophizing Scale: Three items adapted from the Pain Catastrophizing Scale were used, each representing one of the three subscales: rumination, magnification, and helplessness (e.g.,"Tonight, I worried about my [partner's] fatigue"). Responses ranged from 0 (not at all) to 4 (extremely). Co-rumination: "Today, my partner and I talked about how annoying my [his or her] fatigue is") with responses ranging from 0(not at all) to 4(very much). Fatigue: "How fatigued do you feel right now?"). Responses ranged from 0 (not at all) to 10 (as fatigued as I could be) Relationship satisfaction: "How satisfied are you with your relationship right now?"). Responses ranged from 0(not at all satisfied) to 10 (extremely satisfied).
Otto et al. (2015)	Daily capitalization and social support attempts: "Positive leisure or recreational event," and "My spouse/partner did something thoughtful for me." Patients' diaries included two additional positive event items: "Felt physically okay today," and "Got out and did something today that felt good." Diaries also included nine possible negative events, for instance, "Too much work to do," and "Argument or conflict with my spouse/ partner." Patients' diaries included eight additional negative event

	items concerning cancer related health, e.g., "Noticed hair falling out," and "Saw self or scars in mirror." Participants then rated the negativity of the worst event on a Likert-type scale ranging from 0 = slightly undesirable to 6 = extremely undesirable; this rating is referred to as "worst event negativity." Best events were similarly rated on positivity from 0 = slightly positive to 6 = extremely positive; this rating is referred to as "best event positivity." Perceived partner responsiveness: Asked to rate how supportive/reassuring (for the worst event) or enthusiastic (for the best event) his or her partner's response was, using a Likert-type scale ranging from 0 = not at all to 6 = extremely. Daily positive and negative affect: Daily PA and NA were assessed with 12 items selected from the Positive and Negative Affect Schedule-Expanded Form (PANAS-X; Watson & Clark, 1994). For each item, participants were asked to "indicate to what extent you feel this way AT THIS MOMENT" on a Likert-type scale ranging from 0 = very slightly or not at all to 4 = extremely. Daily NA was calculated as the mean of the following seven items: sad, angry, afraid, lonely, blue, scared, and frightened. Daily PA was calculated as the mean of the following five items: interested, determined, enthusiastic, excited, and inspired. Intimacy: "At this moment, how much intimacy/connectedness do you feel with your spouse/partner?" Responses were recorded on a Likert-type scale ranging from 0 = none at all to 6 = an extreme amount. The middle choice, 'happy,' represents the degree of happiness in most relationships. Select the choice that best describes the degree of happiness, all things considered, of your relationships right now." Responses were recorded on a Likert-type scale ranging from 0 = extremely unhappy to 6 = perfect
Paterson, 2019	Self-management strategies: The questions were structured to address: 1) symptom, 2) strategies/behaviours performed, and 3) the outcome of the action. To assess other symptoms or problems for which self-management was performed we asked, "Did you use any other self-care activities (not already mentioned) to help alleviate your symptoms/problems today?" "Please describe the problem/symptom for which you carried out your self-care", "Please describe the self-care tasks". "Generally, did your self-care actions relieve this problem?" was anchored by "not at all/completely" (scale anchor 0-100). Self-management demand and control: "How demanding has self-care been for you?", "how much control have you had over your self-care?" answered by "not at all/completely" (scale anchor 0-100). Finally, participants were asked "What was your most demanding self-care task that you had to do today"? Health-related quality of life: adapted from the EORTC C30 and PR25 questionnaires. "How would you rate your quality of life today?" answered by "very poor/excellent" (scale anchor 0-100), "To what extent have you experienced the following symptoms today? (blood in the urine, constipation, diarrhoea, nausea, pain, tiredness, unable to sleep, urgency to pass urine, urinate frequently day, urinate frequently night, vomiting, erectile dysfunction)" answered "not at all/always" (scale anchor 0-100).
Paterson et al, 2020	Explored qualitative experiences among men affected by cancer to identify methodological complexities in EMA.
Paxton et al, 2022	Daily symptom burden: Items included bleeding, diarrhea, mouth sores, shortness of breath, constipation, bloating, sick, disturbed sleep, dry mouth, numbness or tingling, tenderness, heartburn, tremors, skin dryness, hot flashes, headaches or migraines, joint stiffness, lack of appetite, vomiting, and nausea adapted from the 34-item symptom inventory. Daily pain interference: "how much did pain interfere with" daily activities, work around the home, chores, and social activities. The 4 items were rated on a Likert-type response scale ranging from 1 (not at all) to 5 (very much). Fatigue: Of the 8 items, 6 were rated from 1 (not at all) to 5 (very much), whereas the remaining items were rated from 1 (never) to 5 (always). (No further details reported).

	Physical activity: Exercise Behaviours questionnaire from the Self-management Resource Centre. Response options were zero, 5 to 10 minutes, 10 to less than 20 minutes, 20 to less than 30 minutes, 30 to less than 40 minutes, 40 to less than 50 minutes, and 50 minutes or more. Activity choices were walking, strength training (or stretching), bicycling (or stationary bike), aerobic exercise equipment (Stairmaster, rowing, skiing machine, etc) usage, swimming, or other aerobic activities in the past 24 hours.
Philips et al. (2020)	Affect: Estimate how good or bad you feel right now. Likert scale from 0 (very bad) to 10 (very good) Anxiety: My worries overwhelm me right now. 5 point Likert scale from 1 (strongly disagree) to 5 (strongly agree) Depression: How would you rate your depression right now? 5 point Likert scale from 1 (none) to 5 (very severe) Fatigue: How would you rate your fatigue right now? 5 point Likert scale from 1 (none) to 5 (very severe) Physical activity: To what extent are you able to carry out your everyday physical activities such as walking, climbing stairs, carrying groceries or moving a chair right now? 5 point Likert scale from 1 (completely) to 5 (not at all) Pain: What is your level of pain right now? 0 (no pain) to 10 (worst imaginable pain) Cognitive function: My mind is as sharp as usual right now. 5 point Likert scale from 1 (not at all) to 5 (very much)
Pinto et al, 2020	Sedentary behavior: measured using the waist worn Actigraph (GT3X) accelerometer. Affect and breast cancer related questions: affective valence ("how are you feeling right now?", response scale − 5 to + 5 with − 5 = very bad, 0 = neutral, + 5 = very good), sadness, anxiety, and stress (response scale of 0–10, 0 = not at all, 10 = extremely). Breast cancer and health-related questions included asking if the participant experienced neuropathy, lymphedema, pain, fatigue, and illness. On a scale from 0 to 10 participants were asked to rate their current state for each question with 0 = not at all and 10 = extremely/very much. Participants were also asked about their worry about cancer (response scale of 0–10, 0 = not at all; 10 = extremely).
Ratcliff et al, 2014	Wake-time assessments: Patients asked to estimate the following: (1) minutes they spent in bed (scored as 'total sleep time'; (2) minutes it took them to fall asleep (scored as 'sleep latency'; (3) the number of nocturnal awakenings (scored as 'sleep fragmentation'; (4) the duration of nocturnal awakenings (and (5) their overall quality of sleep rated from 1 (very bad) to 10 (very good). Mood: rated the degree to which the adjective described the way they were feeling at the moment from 1 (not at all) to 5 (extremely). Four bipolar mood-vector scores were derived (i.e., active/inactive, pleasant/unpleasant, calm/anxious, and peppy/drowsy). Scores range from 5 to +5, with positive scores indicating more active, pleasant, calm, and peppy mood. Symptoms: (nausea, fatigue, difficulty concentrating, and numbness) using a 1 (not present) to 10 (as bad as you can imagine) scale.
Rivera-Rivera et al. (2021)	Three items that separately tap into global distress ("How much distress did you experience today?"), anxiety symptoms ("How often did you feel worried, tense, or anxious today?"), and depressive symptoms ("How often did you feel sad, blue, or depressed today?") were used to measure general distress along with single-item measures of cancer-specific distress ("How much did you worry about your cancer today?), cancer-specific wellbeing ("How much change have you experienced in your life as a result of your cancer?"), social support ("How much support did you receive from others today?"), and social constraint ("How often did others dismiss

	your concerns when you tried to express them today?"). 0 to 9 scale where higher scores indicate a higher level of the construct, with exception of cancer-specific wellbeing where 0 = a lot of negative change and 9= a lot of positive change
Schuler et al. (2023)	Daily PROMS: Not reported.
Shiyko et al, 2019	Mindfulness: Items included: ''Just now, I noticed when I became lost in my thoughts, daydreams or fantasies'' (reversed); ''Just now, I found myself observing unpleasant feelings without getting drawn into them,;'' ''Just now, I noticed how my mind tended to cling to certain thoughts and feelings that I was experiencing;'' and ''Just now, I was open to whatever thoughts and feelings I was experiencing'' (the response scale extended from 0—''not at all'' to 4—''very much''). Experience with mindfulness was assessed with a single dichotomous item (yes/no).
Solk et al, 2019	Sleep: "My sleep quality last night was…" 5-point Likert scale from 1 (very poor) to 5 (very good) Physical activity: Did you exercise today? If YES, then: For how long in minutes did you the following kinds of exercise today? STRENUOUS EXERCISE (HEART BEATS RAPIDLY) (i.e., running, jogging, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long-distance bicycling); MODERATE EXERCISE (NOT EXHAUSTING) (i.e., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, alpine skiing, easy swimming, popular and folk dancing); MILD EXERCISE (MINIMAL EFFORT) (i.e., yoga, archery, fishing from riverbank, bowling, horseshoes, golf, snow-moiling, easy walking) Self-efficacy: I am confident I can exercise for at least 30 min today; I am confident I can exercise for at least 30 min tomorrow; I am confident I can replace at least 60 min of sitting and/or lying down with standing or light intensity activities today (i.e., household chores, light walking, etc.); I am confident I can replace at least 60 min of sitting and/or lying down with standing or light intensity activities tomorrow (i.e., household chores, light walking, etc.) All rated 0% to 100% with 10-point increments. Outcome expectation: Exercise will improve my overall body functioning today; Exercise will improve my overall body functioning tomorrow; Exercise will improve my psychological state today; Exercise will improve my psychological state tomorrow; I have plans to engage in some form of exercise for at least 30 min today; I have plans to engage in some form of exercise for at least 30 min tomorrow. All rated 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Mood: My worries overwhelm me right now 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree); How would you rate your depression right now? 5-point Likert scale from 1 (none) to 5 (very severe) Fatigue: How would you rate your fatigue right now? 5-point Likert scale from 1 (none) to 5 (very severe) Physical function: To what extent are you able to carry out your everyday physical activities such as walking, climbing stairs, carrying groceries, or moving a chair right now? 5-point Likert scale from 1 (completely) to 5 (not at all) Pain: What is your level of pain right now? 0 (no pain) to 10 (worst imaginable pain) Cognitive function: My mind is as sharp as usual right now 5-point Likert scale from 1 (not at all) to 5 (very much)
Steffen et al. 2018)	Treatment Day: Treatment Day was a binary variable (0 = no) (1= yes) indicating whether or not someone self-reported chemotherapy or radiation that day. Daily Affect: Positive affect was assessed with two items ("cheerful," "happy") from the Positive Affect and Negative Affect Schedule – Expanded Form (Watson & Clark, 1994) on a scale of 0 (not at all) to 3 (extremely). Two items ("sad," "nervous") from the PANAS-X and two additional items ("depressed" and "anxious") assessed negative affect (0–3 scale).

	Physical Symptoms: physical symptoms (dyspnea, pain, fatigue, appetite, weakness, coughing, nausea) on a scale of 0 = not at all to 3 = very much. Daily hope: At the present time, I am trying to pursue my personal goals and plans," "I can think of many ways to reach my current goals," "There are ways around any problem that I am facing now," and "At this time, I am meeting the goals that I have set for myself." Items were responded to on a scale of 0 (definitely false) to 7 (definitely true) Lung cancer stigma: "I feel guilty because I have lung cancer", "I feel set apart, isolated from the rest of the world", "Having lung cancer makes me feel like I'm a bad person" (all from the Shame subscale), "Some people who know have grown more distant" (Social Isolation subscale), and "Some people act as though it is my fault that I have lung cancer" (Discrimination subscale). Items were selected based on their expected potential to vary daily and face value for assessing lung cancer related stigma. Each item was rated on a 4-point Likert-type scale (0 = strongly disagree to 3 = strongly agree). Social/Role Functioning: "Has your physical condition or medical treatment interfered with your family life today?", "Has your physical condition or medical treatment interfered with your social life today?", "Were you limited in pursuing your hobbies or other leisure time activities?", and "Were you limited in pursuing your work or other daily activities?". Items were rated on a four-point scale with 1 = not at all to 4 = very much. Physical Functioning: "Did you need to stay in a bed or a chair during the day today?", which was rated on the same four point scale used to assess social/role functioning, 1 = not at all to 4 = very much.
Stephenson et al, 2018	Pain: Single item from Brief Pain Inventory scale from 0 (no pain) to 10 (worst pain imaginable) Pain Medication Use: ''Since your last assessment, did you take any medicine for your pain?'' Response options were yes/no. If patients answered yes, they were subsequently asked, ''What type of medicine did you take?'' Response options were prescription medication, over-the-counter medication, or both
van den Berg et al, 2022	Micro EMA survey: surveys contained five randomly selected questions sampled from the SF-36 each day (no further details reported).
Vehling et al., (2018)	Diary measure to assess the frequency of loss orientation, life engagement and coping efforts over the past day. A five- point Likert scale with options 0 = "not at all," 1 = "in one or two moments," 2 = "in several moments," 3 = "more than half of the time" and 4 = "nearly all the time" was used. Not further detailed reported.
Whitaker et al, 2022	Affective valence: "estimate how good or bad you feel right now," from 0 (very bad) to 10 (very good) Anxiety: "my worries overwhelm me right now," from 1 (strongly disagree) to 5 (strongly agree) Depression: "how would you rate your depression right now?" from 1 (none) to 5 (severe) Fatigue: "how would you rate your fatigue right now?" from 1 (none) to 5 (severe) Pain: "what is your level of pain right now?" from 0 (no pain) to 10 (worst imaginable pain) Physical function: "to what extent are you able to carry out your everyday physical activities such as walking, climbing stairs, carrying groceries, or moving a chair right now," from 1 (completely) to 5 (not at all); "are you physically able to go for a walk for at least 15 min right now," from 1 (without any difficulty) to 5 (unable to do)

	Cognitive function: “my mind is as sharp as usual right now,” from 1 (not at all) to 5 (very much).