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Ecological Momentary Interventions To Reduce Addictive Behaviors: A Systematic Review

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Abstract

Purpose of Review The rise of ecological momentary interventions (EMIs) and just-in-time adaptive interventions (JITAIs), which deliver personalized, context-specific support in real-time, has provided new opportunities for addressing addictive behaviors more effectively. This review aimed to qualitatively synthesize the existing evidence to assess the impact of EMIs and JITAIs on reducing various types of addiction.

Recent Findings Previous reviews on EMIs and JITAIs for substance use and smoking cessation have shown mixed results and inconsistent definition of EMI, which poses challenges in interpreting the findings.

Summary The review identified 13 relevant studies that report 12 independent randomized controlled trials, with a total sample size of 2585 participants. The considerable heterogeneity in intervention design, participant characteristics, and implementation fidelity, coupled with the lack of standardized definitions for EMIs and JITAIs, limits our ability to draw definitive conclusions regarding their effectiveness in reducing addictive behaviors. Future research should prioritize standardization of definitions, compliance measurements, behavioral outcomes, and reporting practices to enhance comparability across studies and facilitate the identification of effective intervention components.

Keywords Ecological momentary intervention · Just-in-time adaptive intervention · Addiction · Addictive behaviors · Systematic review

Introduction

The global prevalence of addictions is concerning, ranging from 0.8 to 7.2%, depending on the type of addiction, including substance use, gaming, and gambling disorders [1–4]. Individuals with addiction of any type are at risk of suffering from mental health conditions and impaired social functioning [5, 6]. Given the concerning global prevalence of addictions and their associated health challenges, interventions and support to prevent and mitigate the impacts of addiction are needed. Although professional treatments, such as brief interventions, cognitive-behavioral therapy, and motivational interviewing, have been proven to be effective in reducing addictive behaviors [7, 8], there are limitations to these in-person treatment options. Public stigma experienced by individuals with addictive behaviors [9] may hinder their motivation to seek professional and informal help for their problems [10]. Time constraints, such as limited service hours, and long commute and wait times, are also barriers preventing individuals from seeking professional help [11]. The emergence of digital health interventions, which are designed to deliver health-related interventions via digital technologies [12], has targeted different types of addiction and offered a new avenue for more treatment options. Individuals are allowed to access these treatments without the fear of judgement, as well as time and location constraints [13,14]. This kind of remote support not only has shown high feasibility and acceptability, but also effectiveness in reducing addictive behaviors such as alcohol use [15]. Nonetheless, current digital interventions tend to be static and lack interactive features because they primarily relying on passive content consumption [16], which may lead to decreased engagement [17]. Furthermore, these interventions for addictive behaviors tend to be informational, lacking personalized content [16]. Consequently, they may not be adequately effective in managing cravings

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and triggers, which are transient and strongly influenced by the context in which the person is in.

The recent development of the ecological momentary interventions (EMIs) provides a more advanced approach to addiction treatment. The term "EMIs" was first introduced by Patrick et al. [18] to refer to interventions tailored to ecological momentary assessments (EMAs), which involve repeated sampling of individuals' behaviors and experiences in real time [19], to support individuals at the moments of need in their natural environments. The delivery of EMI content is often triggered by participants' response to EMAs in the context of their everyday lives, whenever and wherever they require such support the most [20, 21]. The scope of EMIs has broadened considerably over the years, particularly with the rise of mobile technology and the development of just-in-time adaptive interventions (JITAIs), which use advanced statistical methods and algorithms to adapt interventions in real time based on contextual and sensor data of one's changing internal state and external environment [22–24]. The personalized and context-specific features of EMIs and JITAIs may be particularly suitable for addressing cravings and triggers in addictive behaviors [25, 26].

Previous reviews on EMIs for addictive behaviors have shown mixed results [27] and lack a unanimous definition of EMI [28], which poses additional challenges in interpreting the results. Moreover, these reviews tend to emphasize specific addictive behaviors (e.g. smoking [28] and substance use [27]. A review covering different types of addiction will give insights into the wider application of EMIs in addiction. The primary aim of this review is to provide qualitative syntheses of additional and more recent evidence on the impacts of EMIs in reducing various types of addictive behaviors. To this end, we seek to facilitate the development of EMIs for addictive behaviors by providing insights for future research and clinical practice.

Methods

We systematically searched PubMed, CINAHL Complete, Embase, PsycINFO, Web of Science, and the Cochrane Library for studies published up to December 2023 in English language. Studies that reported on the efficacy of an EMI in relation to any addictive behavior outcomes were included. For the purpose of this review, an EMI is defined as any approach that delivers targeted interventions or support to individuals in real time and in their natural setting [29]. Reference lists of the reviewed articles were scanned to identify any remaining studies after the initial search. A re-run of the database searches using the original search strategy was conducted on 20 August 2024 (before the final write-up) to identify any potential newly published studies. The study protocol was registered with PROSPERO (CRD42023489526) and the reporting of this manuscript followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [30].

Search Strategy and Selection Criteria

The complete search strategy used for each database was initially developed by all members of the research team. The search terms consisted of two groups of words related to EMIs and addictive behaviors, which were searched within titles, keywords, and abstracts. Complete search strings are provided in Appendix A. Our review followed the Population-Intervention-Comparators-Outcomes framework [31]. Specifically, we included studies that labeled as EMIs and examined the efficacy on addictive behavior outcomes. They must also meet the following criteria: (1) original studies using an experimental or quasi-experimental design in which an EMI was examined as the major intervention; (2) involving participants of any age who engage in addictive behaviors specified in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) [32] or the International Classification of Diseases, Eleventh Edition (ICD-11) [33]; and (3) including at least one outcome measure assessing addictive behaviors. An active control or no intervention served as a comparison. Reviews, commentaries, grey literature, and studies that lacked sufficient quantitative data were excluded. Figure 1 shows the study selection process.

Data Extraction and Quality Assessment

Two trained reviewers performed independent screenings of articles (title, abstract, and full text). Information on the selected studies was organized in the built-in database of Covidence. Cochrane's risk of bias assessment tool was adopted to assess the study quality. Each article was assigned either "low risk," "some concerns," or "high risk" based on the quality of randomization, blinding, data completeness, and any potential selective outcome reporting. Appraisal was independently carried out by the two reviewers. Each component rating was discussed to reach an agreement, with differences reconciled by consulting with two senior reviewers (CKML and EWWC). Figure 2 presents the results of the quality assessment of the reviewed studies. The reviewers extracted data from Covidence using a standardized data extraction checklist, including authors, year of publication, country, study design, sample size of the intervention and control groups, type(s) of addictive behavior examined, mean age of participants, % of female participants, and intervention components, means of treatment and controls, and event numbers of treatment and controls (i.e.,

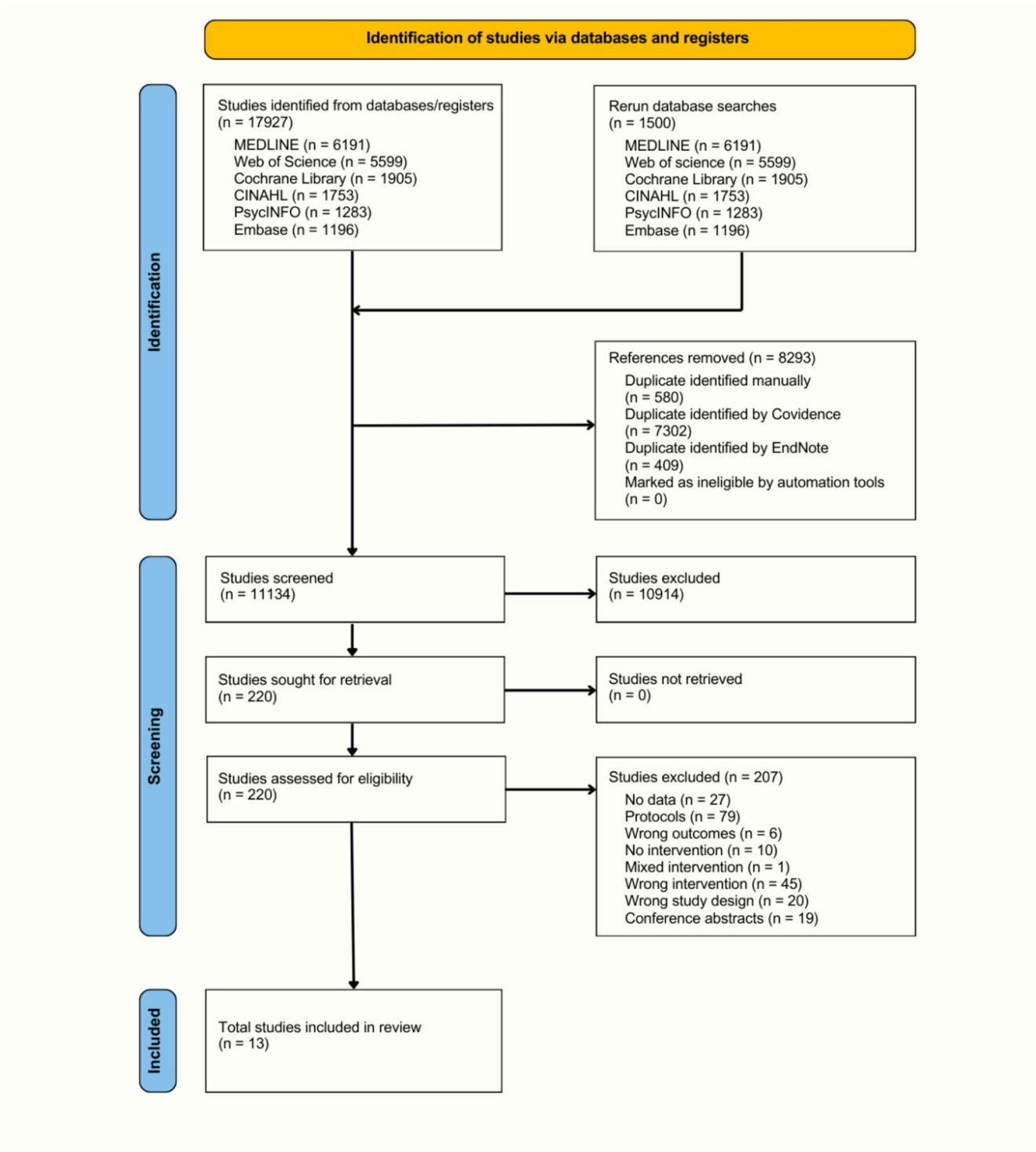

Fig. 1 Flow Chart Illustrating the Literature Selection

the occurrence of outcomes related to the intervention). Due to the small number of included studies and high heterogeneity in study outcomes, intervention designs and dosage, and type of participants, we were unable to conduct a robust meta-analysis.

Results

Study Characteristics and Participants

A total of 13 studies, comprising 12 independent studies

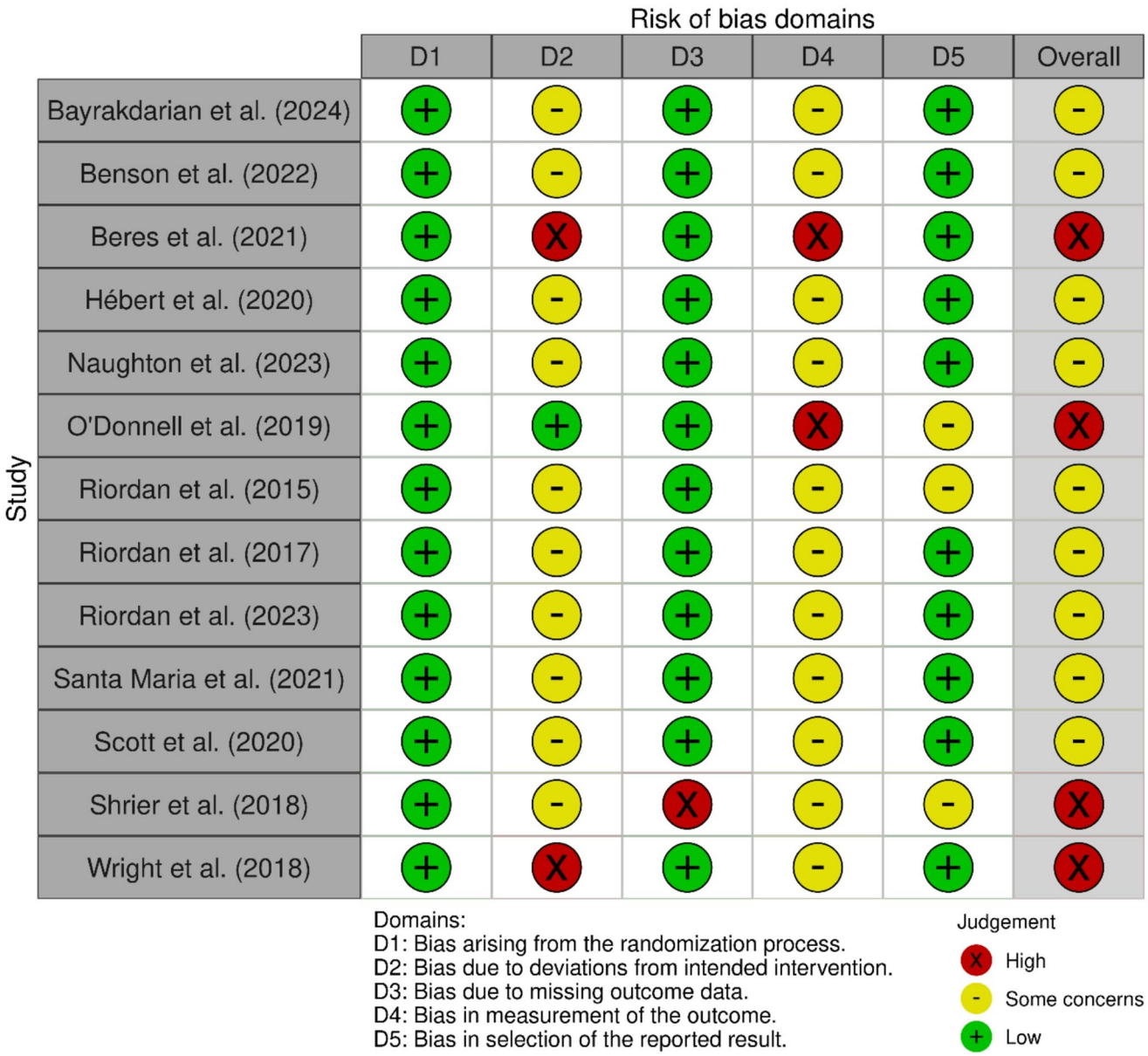

Fig. 2 Quality Assessment of the Reviewed Studies

[34–41, 43–46], met the inclusion criteria and were included in this review. Benson et al. [42] utilized the same study design, intervention procedures, and participant sample as Hebert et al. [41]. Study characteristics are listed in Table 1. The included studies were published between 2015 and 2024. These studies were conducted in various regions: the US ($k=5$), New Zealand ($k=3$), Australia ($k=2$), Uganda ($k=1$), and the UK ($k=1$). The sample size of each study ranged from 45 to 783, with a total number of 2,585 participants. The mean age of the participants ranged from 18.06 to 55.2 years. The sample types included clinical samples, the general population, and school samples. The female participation rates varied widely, ranging from 35.1 to 80%, with an average of 55.1%. The types of addictive behaviors covered across the selected studies were alcohol use ($k=8$), smoking ($k=3$), and substance use ($k=3$), with no studies focusing on behavioral addictions.

Study Design

Control Group

All selected studies were considered as randomized controlled trials (RCT), with seven studies comparing the intervention effects against a control group [34–40]. Five studies included two control groups [41, 43–46]. In seven studies,

Table 1 Characteristics of the selected studies

Author	Year	Country	Addictive Behavior	Study Design	Arm	Control Group	Sample Type	Sample Size (IG/CG)	Mean Age (SD)	Female (%)	EMI Duration	Intervention Component
Bayrakdarian et al. [34]	2024	US	Alcohol use	Pilot RCT	4	Resource brochure review with EMA	Clinical	75 (17; 21; 19/18)	55.2 (15.9)	63%	2 weeks	Text messages contained personalized cues
Benson et al. [42]	2022	US	Smoking	Pilot RCT	3	Access to another application with EMA; attend counseling sessions with EMA	Clinical	72 (24/23; 25)	50.2 (11.9)	49%	5 weeks	Text messages contained lapse prevention support; access to helplines; education materials about cessation advice, coping strategies, and benefits of quitting; and self-monitoring features that tracked EMA compliance and compensation levels
Beres et al. [35]	2021	Uganda	Alcohol use and smoking	Pilot RCT	2	Complete EMA only	General	48 (24/24)	31.4 (7)	48%	Approximate 8.6 weeks (60 days)	Text messages contained health information
Hebert et al. [41]	2020	US	Smoking	Pilot RCT	3	Access to another application with EMA; attend counseling sessions with EMA	Clinical	81 (27/27; 27)	49.6 (11.9)	50%	5 weeks	Text messages contained lapse prevention support; access to helplines; education materials about cessation advice, coping strategies, and benefits of quitting; and self-monitoring features that tracked EMA compliance and compensation levels
Naughton et al. [36]	2023	UK	Smoking	Pilot RCT	2	Receive automated texts related to general health information or resources	General	209 (104/105)	41.1 (10.0)	56%	12 weeks	Text messages contained lapse prevention support; and self-monitoring features that provided feedback on smoking patterns and cravings
O'Donnell et al. [37]	2019	Australia	Alcohol use	Pilot RCT	2	Complete EMA only	General	45 (25/20)	IG: 21.36 (4.15) CG: 22.75 (4.41)	80%	4 weeks	Text messages contained PBS; and self-monitoring features regarding days of PBS use and risky alcohol use
Riordan et al. [38]	2015	New Zealand	Alcohol use	Pilot RCT	2	Complete EMA only	School	130	/	55.4%	1 week	Text messages contained health information and potential social consequences
Riordan et al. [39]	2017	New Zealand	Alcohol use	Pilot RCT	2	Complete EMA only	School	College 1: 116 College 2: 261	College 1: 18.4 (0.8) College 2: 18.4 (0.4)	College 1: 59.8% College 2: 54.4%	1 week	Text messages contained information about potential social consequences

Table 1 (continued)

Author	Year	Country	Addictive Behavior	Study Design	Arm	Control Group	Sample Type	Sample Size (IG/CG)	Mean Age (SD)	Female (%)	EMI Duration	Intervention Component
Riordan et al. [43]	2023	New Zealand	Alcohol use	RCT	3	Complete EMA only; web-based intervention with EMA	School	783	18.06 (0.86)	68.1%	13 weeks	Text messages contained harm reduction skills, information about potential social consequences; and a reminder of students' alcohol use habits; a list of PBS, and self-monitoring features of feedback on alcohol use patterns
Santa Maria et al. [40]	2021	US	Substance use (e.g., marijuana, cocaine, heroin, and others)	Pilot RCT	2	Receive general health behavior-related messages with EMA	Clinical	97 (48/49)	21.2 (2.1)	35.1%	6 weeks	Text messages contained behavior, motivation, and skills information; self-monitoring features regarding goal attainment progress
Scott et al. [46]	2020	US	Alcohol and substance use (e.g., cocaine, heroin, hashish, and others)	RCT	4	Complete EMA only; neither EMA or EMI	Clinical	401 (105; 100/98; 98)	44.2 (11)	39%	24 weeks	Text messages contained relapse risk level and menu of EMIs; access to helplines and support groups; applications related to relaxation and mindfulness; schedule planner and recovery literature
Shrier et al. [44]	2018	US	Substance use (Marijuana)	Pilot RCT	3	Attend counseling sessions with EMA; attend counseling sessions only	Clinical	70 (27/15; 28)	20.7 (1.9)	60%	2 weeks	Text messages contained motivational components
Wright et al. [45]	2018	Australia	Alcohol use	RCT	3	Complete EMA only; no contact	General	269 (90/89; 90)	Aged 18–24: 177 Aged 25–29: 86	48%	12 weeks	Text messages contained feedback on alcohol use and information about health consequences

participants in the control group completed EMA prompts but did not receive an EMI [35, 37, 38, 39,43, 45–46]. Apart from responding to EMA prompts, participants in some control groups received a resource brochure [34], web-based intervention [43], general health behavior-related messages [40], access to another application [41], or counseling sessions [41, 44]. One of the arms in two studies was an active control group that involved receiving automated texts related to general health information or resources [36] or attending counseling sessions [44]; however, participants were not required to respond to EMA prompts. Finally, two studies included a control group in which participants received neither an EMA nor an EMI [45–46].

Intervention Design

Theoretical Approaches

Behavioral approaches and strategies, such as positive reinforcement [35], protective behavioral strategies [37], the Information-Motivation-Behavioral Skills Model [40], and self-managed recovery support [46], were mainly employed in EMIs. Bayrakdarian et al. [34] included intervention components from behavioral economic theory. Motivational interviewing, underpinned by social-cognitive theory, was another technique embedded in several interventions [36, 44, 45]. Nevertheless, it was unclear whether the EMI was grounded in any theoretical framework in four studies [38, 39, 41, 43].

Intervention Content

Across all studies, EMIs utilized text messages as the major intervention component to facilitate behavioral change. Many intervention messages were tailored to participants' experiences, considering contextual factors like self-reported cravings, lapse risks, and current behaviors [35–41, 43–46]. However, there were limited studies focused on deeper personalization related to individual factors such as personal goals, preferences, or characteristics [34, 37, 40, 45]. These messages aimed to deliver health information, behavioral skills, coping strategies, reminders of motivations and goals, potential social consequences, lapse prevention support, and personalized cues regarding future events or alternative activities. Several studies incorporated additional components, such as access to helplines [41, 46], education materials about addiction and recovery [41, 43, 46], and applications related to relaxation and mindfulness exercises [46]. Five studies embodied self-monitoring features that provided feedback on behavioral patterns and cravings [36, 37,43], as well as tracked EMA compliance and compensation levels [41], and goal attainment progress [40].

Intervention Duration

The duration of the interventions varied widely, ranging from one week to 24 weeks, with an average length of 7.6 weeks. Some interventions were specifically timed to coincide with periods when participants were at higher risk of engaging in addictive behaviors, such as during student orientation week in college [38, 39, 43] or during weekend nights, when participants tended to drink [45].

Design of EMI

EMA

All the EMIs involved the use of EMAs, despite differences in the delivery schedule and frequency of EMA prompts across studies. Fixed-time prompts were used in some studies [34, 37–39, 43, 45], while others employed random-time prompts [41, 44, 46]. One study combined both approaches [35]. Individuals were also asked to self-initiate EMAs to report urges or engagement in the study's behaviors of interest [35, 36,41]. Information regarding the delivery schedule of the EMA prompts was not reported in one study [40]. The frequency of EMA prompts ranged from once daily [34, 38] to 10 times per day [45], with some studies prompting every two weeks [39, 43]. Two studies combined EMA with other reporting methods, where respondents were prompted by the app to complete daily diaries [41] and end-of-day surveys [36].

EMI Decision Rules

The timing and content of the interventions delivered to participants were determined by predefined decision rules, based on EMA responses or other data. Three types of decision rules were identified: EMA response-based triggers, geolocation-based triggers, and fixed time intervals. Most studies delivered EMI immediately after participants responded to EMA prompts [35, 37, 40, 41, 44–46]. In addition to lapse risk reported via self-initiated EMAs, Naughton et al. [36] used geolocation records and location sensors to trigger the study's EMI when the participants were near high-risk areas. Four studies delivered EMIs at fixed times (e.g., [34]), in which three EMIs targeted high-risk situations or contexts such as nights with expected social activities [38, 39, 43].

Definitions of EMI

Nine studies employed EMIs as their intervention approach, with a general agreement on the defining characteristics of EMIs as providing timely and personalized behavior change interventions within an individual's natural setting. More specifically, four studies highlighted the use of mobile technology or other device as a medium through which to deliver the intervention for smoking [35], alcohol use [35, 37, 38], and substance use [44]. Additionally, three studies suggested that the EMI relies on EMA behavioral data to tailor support in real time for smoking [35], alcohol use [45, 46], and substance use [46]. The remaining three studies adopted the JITAI as the intervention approach [36, 40, 41]. Hebert et al.'s [41] study used an algorithm to assess lapse risk based on EMA responses related to substance use and delivered tailored messages to address in-the-moment needs. Similarly, personalized information and behavioral skills related to alcohol use and smoking were sent after the completion of an EMA that assessed real-time risk factors and behaviors in another study [40]. Naughton et al. [36] capitalized on a passive technique in which the app provided support related to smoking by tracking participants' geolocations using GPS data.

Participant Engagement

Adherence Rate

Seven studies measured intervention adherence by calculating EMA response rate, either as the percentage of days participants submitted EMA responses [34, 35, 40] or the percentage of EMA prompts completed [37, 41, 44, 45]. Response rates fluctuated significantly across these studies, ranging from 35 to 93%. Riordan et al. [39] reported more than 75% of participants completed EMA reports, while two studies incorporated EMA but did not report response rates to reflect adherence [38, 43].Engagement or utilization of the intervention appears to be another metric of adherence. For the four app-based intervention studies, they reported the number of days participants engaged with the app during the intervention period, yielding participation rates ranging from 29 to 83% [36, 37, 40, 41]. Hebert et al. [41] documented the percentage of participants and the average number of times they accessed each feature and function of the EMI app, while Scott et al. [46] reported adherence rates based on the number of EMIs participants used per week.

Participant Incentives

Incentives were used in 11 studies to encourage participation, including cash, gift cards, mobile data allowances, vouchers, and opportunities to win electronic devices. The most common approach, used in seven studies, involved offering cash rewards or gift cards contingent on the percentage of EMA prompts completed, with additional incentives for attending study visits or follow-ups if necessary [34, 35, 39–41, 44, 45].

Impacts of Interventions

Smoking

Four studies [35, 36, 41, 42] examined intervention impacts on smoking outcomes. Two of the studies reported biochemically verified smoking abstinence through expired carbon monoxide [41] and saliva samples [36], while the other two studies reported changes in the number of cigarettes smoked [35] and smoking urges [42]. Efficacies were observed when self-reporting abstinence was measured as the outcome [36, 41], though statistical significance values varied in comparisons between the corresponding EMI and the usual care control. Beres et al. [35] also found a decrease in cigarette consumption as a result of their EMI despite a nonsignificant difference between groups. In Benson et al.'s pilot RCT [42], increased association between negative affect and smoking urges at within-person level was observed after smokers' quit attempt, and both smartphone-based EMI and traditional clinic-based program helped ameliorate such association. However, the extent of this within-person association did not differ between these two intervention groups.

Substance Use

Three studies reported the effects of EMI in reducing substance use based on the number of days participants used (or did not use) any types of substance (e.g., marijuana, cocaine, heroin, and others) [40, 46] and reports of marijuana use [44]. One study indicated significantly lower marijuana use in both the intervention and control arms, with no significant differences across the arms [44]. In contrast, another study found that the EMI group experienced a significant decrease in drug use compared to the control group [40]. Scott et al.'s study [46] found the combined use of EMI and EMA increased EMI utilization among participants from substance use disorder treatment program, and the increased engagement of EMI predicted better abstinence outcomes.

Alcohol Use

Four studies reported the effects of EMI in terms of the number of drinks [38, 39, 43, 45]; one study measured the frequency of risky drinking [37]; two studies measured the

days participants consumed alcohol [35, 40], while one study measured the severity, frequency, and quantity of alcohol use [34]. Two studies reported the positive effectiveness of EMI: the intervention groups showed a reduction in the number of drinks [39] and severity of alcohol use compared to the control groups at follow-ups [34]. Findings were generally inconsistent. In Beres et al.'s study, a declining trend in alcohol consumption was observed over a 30-day observation period, though the difference in efficacy between the intervention and control groups was insignificant [35]. In another study by O'Donnell et al., no change in risk drinking was found across groups [37]. Riordan et al.'s studies observed mixed findings in alcohol use between EMI and control groups during various measurement periods [38, 39], though the differences were statistically insignificant. A differential effect was also observed between men and women, in which EMI seemed to be more efficacious on female drinkers in reducing alcohol consumption [38]. Santa Maria et al.found a reduction of alcohol use over a 6-week follow-up period, but the between-group difference was statistically insignificant [40]. In the study by Wright et al. [45], the EMI group experienced a nonsignificant increase in the number of drinks at follow-up.

Other Outcomes

Three studies evaluated the intervention effects in relation to the alleviation of the consequences related to alcohol use. Specifically, O'Donnell et al. [37] found slightly better but insignificant protective effects in risky drinking behaviors or associated difficulties in interpersonal relationships, physical health, and work or study performance in the intervention group. Similarly, Riordan et al. [43] reported that participants in the intervention group did not experience a reduction in the negative consequences of alcohol use during follow-up. In contrast, Bayrakdarian et al. [34] showed alcohol use consequences decreased across intervention conditions and increased in the study's control group.

Discussion

The current review synthesizes results from 13 randomized controlled trials to examine the impacts of EMIs in alleviating addictive behaviors. The outcomes examined by the included studies included smoking, substance use, alcohol use, and negative consequences related to alcohol use. Our narrative review found that the current evidence on the impacts of the interventions was inconsistent.

The selected studies varied across study design, participant characteristics, and intervention design, duration and intensity, all of which may influence the intervention process and outcomes. Intervention adherence is a critical factor in interpreting the results and assessing the effectiveness of digital health interventions, including EMIs [47, 48]. Although the recommended rate of completing EMA prompts is 80% [49], the notably lower response rate of 35% [44] reported in one of the included studies, where participants were prompted four to six times daily at random intervals over a two-week intervention period, may reflect potential participant burden associated with the intensity and frequency of EMA schedule. Excessive notifications and prompts may lead to fatigue or annoyance, and ultimately decrease participants' engagement with the interventions [50], in turn affecting intervention outcomes. Almost all studies offered incentives to enhance participation rates. While the use of incentives, especially monetary rewards, is beneficial in boosting compliance rates [51] and the usage of digital health interventions [52], researchers have raised concerns about the sustainability of behavior changes after incentives are removed (e.g., [27]). Future research can explore alternative methods of using monetary rewards to foster longer-lasting effects, encourage participants to take ownership of their behavior changes, and identify other support in order to sustain changes beyond financial incentives.

Intervention messages were the predominant intervention component to facilitate behavioral change in all included studies. Earlier reviews support the utility of text-message interventions for smoking cessation, drug and alcohol addiction [53–55] and suggest that message tailoring and personalization were associated with greater intervention efficacy [54]. Furthermore, personalization of text messages to address individual needs is suggested to be of paramount importance to user engagement and compliance [20, 56]. Hence, it seems reasonable to suggest that personalized intervention messages that are tailored to individuals' needs are a useful component in EMIs. However, the heterogeneity among the included studies impedes our ability to draw a conclusion on whether intervention messages are the key divers to meaningful behavior change in EMIs.

The lack of consensus in regard to the definition of EMIs and JITAIs presents a notable challenge in the field. We only included reviews in our studies that explicitly labelled their interventions as EMIs or JITAIs, a decision made to avoid potential misinterpretation of the intervention approach used in the included studies. However, we found that some of the studies included in our review [34, 38, 39, 43] appear to align more closely with the broader definition offered by Heron and Smyth [29], who described EMI as "treatment that is provided to people during their everyday lives and in natural settings." In these cases, although the interventions are delivered in real-world contexts, they may be tailored using data obtained from pre-intervention assessments rather than EMA (i.e., real-time) input. To facilitate

the development of a unified operational definition of EMIs and JITAIs, we recommend that future research adopt and adhere to the definition proposed by Patrick et al. [18], which specifies that the delivery of personalized interventions in individuals' everyday lives and natural settings should be informed by real-time assessments (i.e., EMA responses) or environmental/contextual data. Such standardization is essential for advancing the field, promoting consistency in intervention design, and enabling more meaningful comparisons across studies. In addition to developing a unified definition, another important step to advance in this field would be to enhance the reporting practices and quality by creating a reporting checklist for EMI. Dao et al. [21] also noted that EMI and EMA components in previous studies have been poorly reported. They have proposed a reporting checklist and suggested that the reporting of some EMA- and EMI-specific components, such as the triggering mechanisms, are critical [21]. Standardization in definitions and reporting practices would not only enhance the transparency and replicability of EMI and JITAI studies, but also facilitate the synthesis of evidence and support the identification of the most effective intervention features.

Strengths and Limitations

First, our review covered different types of addiction, providing insights into the application of EMIs in the wider field of addiction. Another strength is that our review prioritized including the studies that explicitly defined their interventions as EMIs or JITAIs, which helps minimize the possibility of biases in the screening process. Despite these strengths, the small number of included studies, many of which were pilot randomized controlled trials with small sample sizes, limits the validity and generalizability of the findings. The variability in study samples, methodologies of EMAs and EMIs, measurement tools, comparison groups, and outcomes further constraints the synthesis of results to be interpreted. Moreover, all of the studies included in this review focused exclusively on substance addiction. For behavioral addiction, we identified one feasibility study of EMI for problem gambling [57], which reported preliminary findings supporting the use of EMI in preventing gambling episodes. However, the study was not included in the current review due to not meeting the study eligibility criteria. Whether the findings from this review are generalizable to behavioral addictions warrants further research.

Conclusion and Future Directions

Despite the existence of EMI research in addiction for over a decade, there has been insufficient advancement in the rigor of the research design employed. This has limited the strength of available evidence from which to draw conclusions about the effects on the reduction of addictive behaviors. The absence of a clear consensus on the definition of EMIs, coupled with insufficient robust evidence demonstrating EMIs' effectiveness for addictive behaviors specifically, may have impeded the development of this innovative approach in the field of addiction. EMIs are thought to be a promising approach in addressing critical aspects of addiction, such as cravings, internal and external triggers, and high-risk situations [58]. However, more studies are needed to substantiate their effectiveness before drawing definite conclusions. To advance the field, future studies should prioritize the development of consistent and standardized methods that can measure compliance with EMIs and outcomes, allowing for greater comparability across studies. Passive data collection methods, such as physiological sensors or ecological indicators (e.g., GPS tracking), may be considered to reduce participant burden in responding to EMA surveys while providing real-time data for intervention tailoring. Implementing faster methods, such as emoji selections, slider scales, or speech-to-text technology, to quickly log data that passive sensors cannot capture should also be explored to reduce the burden. Future research should investigate whether and to what extent multi-component interventions are more effective than single-component approaches. Determining the optimal frequency and duration of EMIs is also crucial by investigating how often the EMIs should be delivered and the length of treatment necessary to achieve a meaningful impact on behavioral change and adherence. By addressing these considerations, EMIs may better support individuals in managing addictive behaviors, leading to more effective and sustained health outcomes.

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  A meta-analytic review using PubMed, PsycINFO, Web of Science and Google Scholar databases. A total of 23 meta-analyses were included. The psychosocial treatments included in the review showed

small-to-moderate effects on various substance use disorders.

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  A meta-analytic review using Medline, Scopus, CENTRAL, PsycINFO, and ProQuest databases. A total of 10 studies were included for qualitative and quantitative synthesis. The study suggested that the reviewed interventions appear to be beneficial for smoking cessation.

- O'Logbon J, Wickersham A, Williamson C, Leightley D. The effectiveness of digital health technologies for reducing substance use among young people: a systematic review & meta-analysis. J Ment Health. 2023 Sep 4;1–29. https://doi.org/10.1080/09638237.2023.2245902.

  A meta-analytic review using Embase, Global Health, Medline, PsycINFO, Web of Science databases. A total of 42 studies were included for qualitative synthesis and 18 studies for quantitative synthesis. The study concluded that the effectiveness of digital interventions for reducing substance use is generally weak.

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  A meta-analytic review using Academic Search Complete, PsycArticles, and PsycInfo databases. A total of 477 articles were identified. The study examined factors associated with compliance and dropout rate of ecological momentary assessment.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40429-025-00666-3.

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Declarations

Ethics Approval and Consent to Participate No animal or human subjects were used by the authors in this study.

Competing Interests The authors declare no competing interests.

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