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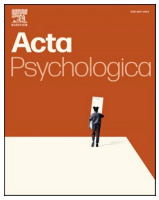

Effectiveness of smartphone interventions as continuing care for substance use disorders: A systematic review

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ABSTRACT

As a chronic disease with consistent relapse rates, substance use disorders (SUD) require a continuity-of-care approach. Unfortunately, many patients do not have access to continuing care. This systematic review analysed the current scientific knowledge to better understand if app-based smartphone interventions can be an effective alternative. The databases Cochrane Library, PubMed, Web of Science, and PsycINFO were used to find experimental and quasi-experimental studies investigating the effectiveness of a smartphone intervention in individuals who had completed treatment for SUD. After removing duplicates, a total of 1488 studies were screened, with 48 being selected for a full-text review. Four studies met all the criteria, with one other being added by identification through other resources, making a total of 5 studies included in the present review. Out of the four studies using a control group, only one found no significant differences in favour of the experimental group. That study used an active control group and compared the smartphone intervention to its therapeutic group equivalent. There were no significant differences between the two experimental groups. Overall, the results indicate that app-based smartphone interventions can be an effective alternative to traditional forms of continuing care. However, literature is still scarce, and more research needs to be made on this subject.

This systematic review is registered at PROSPERO with the identifier [CRD42021272070].

1. Introduction

Substance use disorders (SUD) are a global health crisis. According to the United Nations Office on Drugs and Crime (UNODC, n.d.), in 2018, around 275 million people used substances and over 36 million had a substance use disorder. Unfortunately, this number is expected to keep rising.

Substance abuse has been associated with physical and mental health problems (Oliveira, 2011) and with an increase in premature mortality from non-medical and medical causes (Kendler et al., 2017). These individual costs along with severe societal and economic ones can explain the growing interest of the scientific and public health communities regarding the treatment of SUD.

Despite the considerable developments that have been made in the last decades, treatment outcomes for these disorders remain poor. According to the National Institute on Drug Abuse (Preface, n.d.; McLellan et al., 2000), relapse rates for SUD fall between 40 and 60 %. This data is in line with recent studies (Andersson et al., 2019; Kabisa et al., 2021) conducted in different countries, with different cultural and treatment realities. Interestingly, the relapse rates for SUD are comparable to those of chronic illnesses such as asthma and hypertension, with both showing relapse rates between 50 and 70 % (McLellan et al., 2000).

In addition to consistent relapse rates, recent evidence suggests the existence of genetic vulnerability associated with addiction, as well as persistent brain changes resulting from heavy substance use (Morse, 2018). Altogether, these findings led to a new conception of SUD, and addiction in general, as a chronic disease (Surgeon & M.H.S.A.O., n.d.; Morse, 2018). This shift in how we think about SUD has been followed by a slow but important change in how we approach its treatment goals - from cure to management, and in its modality - from episodic to longitudinal.

The successful control of chronic diseases has been known to depend on how well individuals manage their condition with the aid of healthcare professionals, with research highlighting the importance of

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continuing care models (or continuity-of-care). These models are reported to improve the patient's self-care knowledge and quality of life, as well as reduce the need to stay hospitalized and associated medical costs (Chen et al., 2014). The above-mentioned models, known as discharge planning, case management, or a mix of the two (Chen et al., 2014), postulate the existence of a personalized plan where it is assessed the specific needs of a given patient, the patient's treatment goals, and resources having to be used to optimize the healthcare and psychosocial possible goals and outcomes. In parallel with models of other chronic conditions, continuing care for SUD proposes that patients who are discharged from intense levels of treatment (commonly residential) would also benefit from a lower intensity and continuing care while being reintegrated into their normal environment (Dennis & Scott, 2007; McKay et al., 2005) as it is reported to maintain treatment gains and prevent possible relapses.

However, despite the evidence of the positive effects of continuing care (McKay et al., 2021), some challenges make it difficult to fully profit from the continuing care advantages. While some patients don't have access to it, data suggests that the ones who do, frequently drop out of the treatment. Contributing factors are the associated high treatment burden, low convenience of the continuing care model, employment or family responsibilities, and lack of transportation, illness, or disabilities (McKay et al., 2021). As such, there has been a push for new adaptive models that strive to adapt the protocols to the patient's specific needs, put more emphasis on self-care, and have a greater reliance on new technologies (McKay, 2009).

The use of smartphone applications has been of particular interest because of its low economic cost and because it allows the patient to start continuing care immediately (Paquette et al., 2021; Passetti et al., 2016). Moreover, as this modality doesn't require patients to make any major adjustments to their schedule nor does it restrict them to a specific location, the use of smartphones as a treatment tool presents itself as a promising option.

In this line of thought, McKay et al. (2005) explored the possibilities of remote continuing care in their studies. They compared three types of 12-week continuing care treatments: (1) standard group counselling twice a week (STND), (2) cognitive-behavioural relapse prevention, also twice a week (RP), and lastly, (3) weekly telephone-based monitoring and brief counselling contacts combined with weekly supportive group sessions in the first four weeks (TEL). Their results suggest that telephone-based monitoring is as effective as more intense face-to-face treatments for most substance-dependent patients (McKay et al., 2005). On that account, it appears technologies can be used to avoid the reported drop-out of the treatment due to logistic difficulties of transport or others previously mentioned. A more recent review (McKay et al., 2021) also suggests that remote continuing care might have a particularly important effect on patients at a higher risk of relapse, as well as shows that longer duration and higher engagement in treatment contributed to more consistently positive results.

An integrative review looking into the use of app-based smartphone interventions for the long-term management of chronic diseases found these interventions effective in monitoring patients' symptoms, supporting them, and/or managing chronic illness in some aspects (Wang et al., 2014). Included in the studies selected for the review were studies that focused on mental health diagnoses, such as depression and personality disorders. All but one reported significant improvement in the management of the disease following the use of a smartphone intervention. The results of studies investigating the use of smartphone interventions as continuing care for alcohol use disorders have also been encouraging. Gustafson et al. (2014) did a randomized controlled trial on the effectiveness of the smartphone application Addiction–Comprehensive Health Enhancement Support System (A-CHESS) for individuals who had completed residential treatment for alcohol dependence. The results indicated that patients who used the A-CHESS app presented significantly fewer risky drinking days than those in the control group both at the end of the intervention and after 4 months following its end. A more recent report of a randomized controlled trial on the effectiveness of the same smartphone intervention obtained similar results (McKay et al., 2021). McKay et al. (2021) found that the A-CHESS app provided effective remote continuing care for alcohol use disorder.

Despite the consensus regarding the importance of continuing care for SUD and the growing interest in the use of smartphone interventions as a cost-effective and practical alternative, to our knowledge, no systematic or meta-analytic review has been conducted on this topic. We believe that analysing the effectiveness of these interventions is not only pertinent but timely, given that many individuals with SUD struggle to access adequate continuing care. As such, the present systematic review aims to understand if relapse prevention/addiction treatment smartphone applications can be an effective form of continuing care/aftercare for individuals who have completed treatment (outpatient or inpatient) for substance use disorders. Additionally, if the necessary data is available, we would like to explore the comparative effectiveness of this approach to other more traditional forms of continuing care. To achieve these goals, we intend to answer the following questions:

I. Does the use of relapse prevention/addiction treatment smartphone applications after the conclusion of outpatient or inpatient treatment for substance use disorder lead to better recovery outcomes (e.g., relapse rate, days of use)?
II. How do relapse prevention/addiction treatment smartphone applications compare to other forms of continuing care/aftercare regarding recovery outcomes (e.g., relapse rate, days of use)?

2. Method

2.1. Protocol registration

This review has been registered and published in the International Prospective Register of Systematic Reviews (PROSPERO) under identification number CRD42021272070.

2.2. Search strategy

The present review was based on The Population, Intervention, Comparison, and Outcome (PICO) strategy of the Joanna Briggs Institute (JBI (Aromataris & Munn, 2017)). The search strategy involved terms related to substance use disorders and smartphone applications. Publication dates and periods were not restricted so that all relevant studies would be included. The sources searched included the Cochrane Library, PubMed, Web of Science, and PsycINFO and the search terms were found using DeCS and MEDLINE MeSH. Concepts were combined with the Boolean operator “AND” and terms within concepts linked with the operator “OR”. The search string was as follows: ((mobile OR mobile phone OR mobile phone app OR cell phone app OR mobile application OR mobile app OR mobile intervention OR smartphone OR smartphone app OR mHealth) AND (addict or substance use OR substance use disorder OR substance abuse OR alcohol OR drug OR drug abuse OR alcohol use disorder OR opioid OR heroin OR marijuana OR cannabis OR stimulant OR cocaine OR amphetamine OR methamphetamine OR hallucinogen OR ecstasy OR polydrug) AND (follow-up OR aftercare OR step-down care OR stepdown care OR continuing care OR relapse prevention)).

Initially, both titles and abstracts from the retrieved studies were screened by two independent reviewers and checked for inclusion/exclusion criteria. A third reviewer resolved any conflict that arose. Afterward, the full text of the studies selected as being eligible for the review was analysed by the same two initial reviewers. In addition, references to the articles were screened for additional relevant studies, which likewise underwent the same data extraction process. Finally, a hand search was carried out to consider potentially relevant unpublished studies or grey literature.

2.3. Study selection

Type of Study: Experimental and quasi-experimental studies with articles written in English, Portuguese, or Spanish.
Type of population: Adults (aged ≥18 years) who completed an in-patient or outpatient treatment for substance use disorders (as diagnosed using any recognized diagnostic criteria).
Type of intervention: Any type of relapse prevention/addiction treatment smartphone app used as a form of continuing care after the completion of an in-patient or outpatient treatment for substance use disorders.
Type of comparators: Both studies with and without a comparator group were considered. For those with a comparator group, we considered the following possible comparators: individuals who completed an in-patient or outpatient treatment but did not receive any form of continuing care/aftercare (including relapse prevention/addiction treatment smartphone apps); individuals who completed an in-patient or outpatient treatment and received a traditional form of continuing care/aftercare (not involving smartphone apps).

2.4. Assessment of study quality

The quality assessment measures were chosen according to the type of studies found and included in the review (upon meeting the inclusion criteria). We used the Cochrane Risk of Bias Tool for Randomized Controlled Trials (RCT) (Higgins et al., 2011) and the Joanna Briggs Institute (JBI; Aromataris & Munn, 2017) critical appraisal checklist for quasi-experimental studies.

2.5. Data extraction

Data were extracted considering the Cochrane Handbook for Systematic Reviews. The analysis considered the following data: country, study design, population/substance use disorder, sample size, gender distribution, age range and mean, type of treatment, smartphone app used, smartphone app characteristics, duration of smartphone app use, smartphone app engagement, primary and secondary outcome descriptions and outcomes measures, key findings, limitations.

2.6. Data synthesis

A narrative approach was used to synthesize the findings from the included studies. It was structured around the different types of data and outcomes of interest. Due to the heterogeneity of the studies, it was not possible to perform a meta-analysis.

3. Results

3.1. Literature search/study selection process

Fig. 1 presents the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart that describes the selection process of the studies included in this review.

Through the search in the databases, a total of 2263 studies were obtained (Pubmed n = 411; Web of Science n = 482; Cochrane Library n = 35; PsycINFO n = 394 and Scopus n = 941). There were 775 duplicates removed. From a total of 1488 studies, 48 studies were selected for a full-text review after the initial screening. The remaining 1440 studies were excluded because they did not meet the following inclusion criteria: the article was not written in English, Portuguese, or Spanish

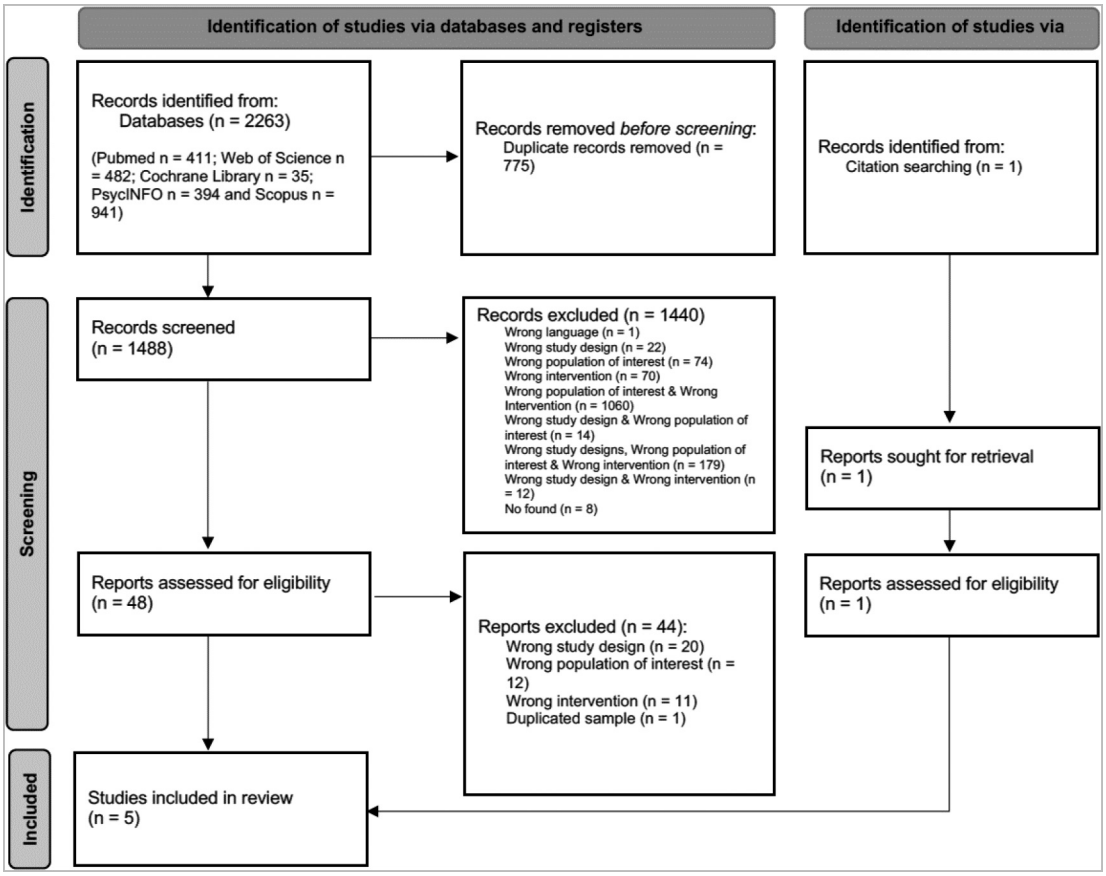

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

(Wrong language; n = 1); the study did not have an experimental or quasi-experimental design (Wrong study design; n = 22); the study population were not adults who completed treatment for SUD (Wrong population of interest; n = 74); the study intervention was not a relapse prevention/addiction treatment smartphone app used as a form of continuing care (Wrong intervention; n = 70); the Wrong population of interest & Wrong Intervention (n = 1060); Wrong study design & Wrong population of interest (n = 14); Wrong study design, Wrong population of interest & Wrong intervention (n = 179); Wrong study design & Wrong intervention (n = 12); and, full article not found (n = 8).

After the full-text review, another 44 studies were excluded for the following reasons: Wrong study design (n = 20); Wrong population of interest (n = 12); Wrong intervention (n = 11); and duplicated sample (n = 1).

Finally, an additional record identified through other sources was included (n = 1), making a total of 5 of the studies eligible and included in the present review as they met all the previously defined inclusion criteria.

3.2. Participant characteristics

In Table 1, the characteristics of the participants are presented.

3.2.1. Date & country

The five different studies included in the review had a variety of multicultural contexts, having two (40 %) of them being conducted in the USA but in different time frames 2014 (Gustafson et al., 2014) and 2021 (McKay et al., 2021), another (20 %) in 2017 in Taiwan (You et al., 2017), another in 2019 in Denmark (Mellentin et al., 2019) and the last one in 2020 in Sweden (Hamalainen et al., 2020).

3.2.2. Age and gender

The sample size for the studies in the review ranged from 38 (You et al., 2017) to 349 (Gustafson et al., 2014). Regarding age, only one study (20 %) presented a mean value below 40 years (M = 38, SD = 10; Gustafson et al., 2014), three studies (60 %) reported a mean value between 40 and 50 years (McKay et al., 2021; Mellentin et al., 2019; You et al., 2017), and another (20 %) a mean value above 50 years (Hamalainen et al., 2020).

Concerning gender, all studies had male-majority samples. Nonetheless, two studies (40 %) had a more balanced sample with 61 % (Gustafson et al., 2014) and 66.1 % (Hamalainen et al., 2020) male representation respectively. The remaining study that presented the relevant data (Mellentin et al., 2019), showed 72 %, 77 %, and 83 % male representation in each of the study groups.

3.2.3. Substance type

All 5 studies included in the present review (100 %) used participants with alcohol use disorders (AUD) or alcohol dependence (AD).

3.3. Study characteristics

In Table 2, the characteristics of the included studies are summarized.

3.3.1. Study design

Of the five studies included in the present review, one (20 %) had a quasi-experimental design (Mellentin et al., 2019), while the other four used a randomized-controlled trial (80 %) (Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; You et al., 2017).

3.3.2. Control group

Four of the five studies in the review (80 %; Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; Mellentin et al., 2019) used some type of control group. Three studies (60 %; Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021), used a passive control with treatment as usual (TAU) as the intervention, one (20 %) used a passive and an active control group (Mellentin et al., 2019). However, despite using a passive control group (TAU), the study of McKay et al. (2021) uses a 2 × 2 design with a four-group comparison analysing outcomes between all groups, therefore presenting a strong control condition. Lastly, the study by You et al. (2017) was the only one that did not use any control.

3.3.3. Intervention/smartphone application

All the studies focused on smartphone applications designed to provide continuing support to individuals with AUD or AD who already completed some type of primary treatment. Of the three studies that indicated the theoretical background of their smartphone applications, one (33,3 %) was based on self-determination theory (Gustafson et al., 2014), another (33,3 %) relied on different psychosocial interventions for AUD such as cognitive-behavioural therapy, motivational enhancement therapy, contingency management, and 12-step facilitation therapy (You et al., 2017), and the last one (33,3 %), was grounded on a cue exposure treatment manual (Mellentin et al., 2019). In their study, McKay et al. (2021) used two telephone-based interventions: the telephone monitoring and counselling (TMC) and ACHESS, the latter being the same smartphone application from another study analysed in this review (Gustafson et al., 2014).

The features provided by the applications and interventions differed considerably, but all offered some type of monitoring (e.g., daily check-ins, mood sampling, progress, and emotional state monitoring) and coping/easing distress strategies (Gustafson et al., 2014; Hamalainen

Table 1
Subject characteristics.

Author (year)	Country	Population	n	Age (M ± SD), years	Gender (% male)	Drug
Gustafson et al. (2014)	USA	Adults with alcohol use disorders that completed residential treatment	349	M = 38, SD = 10	61 %	Alcohol
You et al. (2017)	Taiwan	Adults with alcohol dependence undergoing an outpatient maintenance program for abstinence	38	M = 42.2, SD = 7.4	NP	Alcohol
Mellentin et al. (2019)	Denmark	Adults with alcohol use disorders that completed primary treatment	Total: 164 CET app (n = 54) CET group (n = 54) Aftercare as usual (n = 56)	CET app (M = 46, SD = 14) CET group (M = 48, SD = 13) Aftercare as usual (M = 45, SD = 12)	CET app (72 %) CET group (83 %) Aftercare as usual (77 %)	Alcohol
Hamalainen et al. (2020)	Sweden	Aftercare patients with alcohol use disorders	115	Males (M = 53, SD = 9) Females (M = 52, SD = 8)	66,1 %	Alcohol
McKay et al. (2021)	USA	Adults with moderate to severe alcohol use disorders undergoing intense outpatient programs	262	M = 46,9, SD = 7.4	71 %	Alcohol and other drugs

Note. NP, not provided.

Table 2
Study characteristics.

Author (year)	Randomization	Blindness	Control group (active or passive)	Outcome measures	Data collection
Gustafson et al. (2014)	Yes	Un-blinded	Passive	Risky drinking days (>4 standard drinks for men and 3 for women in 2 h; previous 30 days) Abstinence (previous 30 days) Negative consequences of drinking (The Short Inventory of Problems – Revised)	4, 8, and 12 months
You et al. (2017)	No	–	No control	Alcohol Timeline Followback (TLFB) - time to relapse; the number of drinking days; average drinks consumed per week; the number of drinks per drinking day; the number of heavy drinking days; cumulative abstinence days; abstinence and retention rate Visual Analog Score for craving (VAS) Beck Depression Inventory (BDI) Beck Anxiety Inventory (BAI) WHO Quality of Life-Brief (WHOQOL-BREF) Satisfaction with Life Scale (SWLS)	1, 2, 4, 8, and 12 weeks for the TLFB variables; 0, 4, 8, and 12 weeks for other variables
Mellentin et al. (2019)	Yes	Single-blinded	Active & Passive	Alcohol Timeline Followback (TLFB) - sensible drinking; abstinence; drinking days; days with excessive drinking (drinking >5 standard drinks per day) Visual Analog Scale (VAS) 22-item Urge-Specific Coping Skills Questionnaire (USCSQ) Real-time cue-induced cravings (scale of 0–10, with 0 representing no cravings and 10 severe cravings)	2 and 6 months
Hamalainen et al. (2020)	Yes	NP	Passive	Alcohol Timeline Followback (TLFB) - standard drinks per drinking day (DDD); days of abstinence (AbsDay); heavy drinking days (HDDs; 4 or more drinks per day for females and 5 or more drinks per day for males). Positive breathalyser test results (eHealth system) Phosphatidyl ethanol (PEth, 16:0/18:1, in μmol/L) in blood (LC-MS/MS) Alcohol Use Disorder Identification Test (AUDIT) Short Alcohol Dependence Data (SADD) Quality-of-Life (EQ-5D)	1, 2, 3, 6 and 12 for the TLFB variables 5 visits after baseline visit for PEth 1, 6, and 12 months for AUDIT, SADD, EQ-5D
McKay et al. (2021)	Yes	Un-blinded	Passive	Structured Clinical Interview for DSM-IV (SCID); Mini-international Neuropsychiatric Interview (M.I.N.I.) Timeline Followback (TLFB) for frequency of alcohol, heavy alcohol, and cocaine Addiction Severity Index (ASI) The Short Inventory of Problems (SIP) Short Form survey (SF-12) Urine toxicology	3, 6, 9, 12, and 18 months follow-up for the TLFB, ASI, SIP, SF-12, and urine toxicology

Note. NP, not provided.

et al., 2020; McKay et al., 2021; Mellentin et al., 2019; You et al., 2017). Three of the smartphone applications (75 %) also provided some type of emergency feature that the participants could use if they needed more support, such as a panic button (Gustafson et al., 2014), a help button (Hamalainen et al., 2020), or direct contact with a therapist (Mellentin et al., 2019). Two of the five studies (40 %), used a combination of a smartphone application and a connected cell-based pocket-sized breathalyser, allowing for the self-test by the part of the users of the app (Hamalainen et al., 2020; You et al., 2017).

Concerning conditions of use, three of the four smartphone applications (75 %) allowed unlimited access to most features (Gustafson et al., 2014; Hamalainen et al., 2020; You et al., 2017), except for the self-test for alcohol consumption through the cell-based breathalyser, which was restricted to scheduled times (Hamalainen et al., 2020). You et al. (2017) did not provide information about the restrictions on self-test on the smartphone application in their study, SoberDiary. With regards to the smartphone application in the study by Mellentin et al. (2019), it was only available during the opening hours of the alcohol outpatient clinic (Monday to Friday - 9 am to 6 pm). Moreover, the exposure feature could only be used once a day, up to four times a week (maximum of 32 sessions of approximately 15 min each).

Table 3 provides a summary of the characteristics of each Intervention/Smartphone Application.

3.4. Key findings

Table 4 presents the main results of the five studies included in the review.

Of the four studies that compared a smartphone application intervention to aftercare as usual (Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; Mellentin et al., 2019), two of them (50 %) found significant differences between the experimental and the control group (Gustafson et al., 2014; McKay et al., 2021).

On one hand, the study by Gustafson et al. (2014), demonstrated that participants who used the A-CHESS application in addition to treatment as usual (TAU) reported significantly fewer risky drinking days both at the end of the intervention (8 months) and after 4 months of the of follow-up when compared to the control group. On another hand, McKay et al. (2021) demonstrated that telephone monitoring and counselling (TMC), A-CHESS, and the combination of the two (TMC and A-CHESS) produced a lower frequency of heavy drinking days than the control group (TAU). They have also found that TMC and both TMC and A-CHESS produced better results on one of the secondary outcome measures – any alcohol use – than the TAU group. Altogether their results suggest that adding TMC, A-CHESS, and the combination of two to intensive outpatient treatment reduced heavy drinking by approximately 50 % over 12 months while interventions were provided, with positive effects being maintained in the following 6 months for the group having both TMC and A-CHESS.

Table 3
Intervention/smartphone application characteristics.

Author (year)	Intervention/ smartphone app	Description	Features	App usage duration/conditions
Gustafson et al. (2014) McKay et al. (2021)	A-CHESS	A-CHESS was created to improve continuing care for AUDs. It is based on self-determination theory (SDT), which considers that an individual's adaptive functioning is mostly reliant on 3 needs: being perceived as competent, feeling connected to others, and feeling internally motivated.	Support team (the participant can add persons to the list) Panic button (provides alternative strategies such as reaching out to others, relaxation, learning, and recovery motivation) News (about the intervention or addiction in general) Easing distress strategies (audio guides/lessons) Messages Discussion groups (in-app) Events (lists of events of the day near the participant) Stories from the community (audio of other people involved in the community sharing their stories) Weekly surveys Team feed Meeting locator Recovery info Recovery podcasts Possibility to personalize settings (high-risk locations through GPS, daily check-in time, sobriety date, recovery motivation, and notifications)	Access to app features not restricted Participants were asked to complete a reduced version of the Brief Alcohol Monitoring (BAM) Index weekly (feedback from therapist) Caregiver monitoring for 8 months
You et al. (2017)	SoberDiary	SoberDiary was based on various psychosocial interventions for alcohol use disorder including cognitive-behavioural therapy, motivational enhancement therapy, contingency management, and 12-step facilitation therapy.	Self-alcohol use detection (Bluetooth breathalyser) Monitoring emotional state and cravings (emotion index and craving index) Strategy suggestions (according to test results) Progress monitoring and feedback Storytelling visualization Mood sampling (voice recording)	Caregiver monitoring for 12 weeks
Mellentin et al. (2019)	Cue Exposure Therapy	The Cue Exposure Therapy app was based on a cue exposure treatment manual. Cue exposure therapy (CET) is an approach to treating AUD that aims to reduce cue-induced cravings through repeated exposure to relevant alcohol cues and deterrence of habitual drinking responses.	Exposure to personalized alcohol cues through video (individuals can select their preferred beverage) Coping strategies Direct phone number to a CET therapist	App only accessible during opening hours of the alcohol outpatient clinic (Monday to Friday from 9 am to 6 pm) Exposure feature available up to once a day, four times a week (maximum of 32 sessions of approximately 15 min each) Caregiver monitoring for 8 weeks
Hamalainen et al. (2020)	Previct Alcohol® (Kontigo Care AB)	Previct Alcohol® Kontigo Care AB is an eHealth system created by Kontigo Care AB. It consists of a smartphone app for patients with a connected fuel cell-based pocket-sized breathalyser and a web-based portal for the caregiver.	Self-alcohol use detection (Breathalyser) Daily check-ins Monitoring emotional state Coping strategies Help button Feedback from caregiver	Scheduled breathalyser tests between 2 and 4 times a day (personalized according to participant) Caregiver monitoring for 12 weeks
McKay et al. (2021)	The telephone monitoring and counseling (TMC)	The TMC was based on the Stress and Coping Theory and on the Social Control Theory. It attempts to aid patients in the long-term management of substance use disorders.	Direct contact with a counselor Progress assessment done in the beginning of every call	Provides regular and sustained contact with counselor: weekly calls during the first month, twice a month for the next three months, monthly for the months 4 to 7, and every other month from the month 8 to 12. Each call can be initiated either by the counselor or the patient, and last between 15 and 30 min each.

Regarding the other two studies, Hamalainen et al. (2020) found that despite the lack of significant differences in the TLFB results, the experimental group showed significantly lower PEth results at 2 and 3 months when compared to the control group. The discrepancy between the two outcomes was bigger in participants for whom the goal was complete abstinence as opposed to controlled drinking. Finally, Mellentin et al. (2019) found that even though there were no significant differences between the groups on drinking and craving outcomes, the participants who utilized Previct Alcohol® showed increased use of urge-specific coping skills compared to aftercare as usual. This effect was reduced at the 6-month follow-up. Moreover, there were no significant differences between the CET experimental groups.

You et al. (2017) did not use a comparator group but studied the impact of adherence on the effectiveness of the smartphone application SoberDiary. They found that participants who were highly adherent presented fewer drinking days and drinks consumed per week, as well as a higher cumulative number of abstinence days and abstinence rate when compared to participants who were less adherent.

3.5. Risk of bias

Cochrane Risk of Bias Tool (Higgins et al., 2011) was the tool used in

Table 4
Key findings.

Author (year)	Aims	Key findings
Gustafson et al. (2014)	Investigate whether patients using the A-CHESS application after the conclusion of residential treatment for AUDs would present fewer risky drinking days than control-group patients.	Participants in the experimental group (A-CHESS application) reported significantly less risky drinking both at the end of the treatment and after 4 months following the intervention when compared to the patients in the control group.
You et al. (2017)	Evaluate the benefits of the SoberDiary application coupled with a Bluetooth breathalyser to assist patients with AD and undergoing an outpatient maintenance program for abstinence.	Participants who were highly adherent to the SoberDiary application recorded fewer drinking days and drinks consumed per week, and a higher cumulative number of abstinence days and abstinence rate when compared with participants who were less adherent. They also presented less pronounced anxiety and superior quality of life.
Mellentin et al. (2019)	Examine whether CET as aftercare would increase the effectiveness of primary treatment with cognitive behaviour therapy and whether CET delivered through a smartphone application would show similar effectiveness to CET delivered via group sessions.	There were no significant differences between the experimental groups (CET group and CET app) and the aftercare as usual (AAU) on drinking and craving outcomes. The experimental groups showed increased use of urge-specific coping skills compared to AAU at posttreatment, but this effect was reduced at the 6-month follow-up. There were no significant differences between the two experimental groups on any outcomes.
Hamalainen et al. (2020)	Study the efficacy and monitoring capabilities of the Previct Alcohol®, a breathalyser-based eHealth system for patients with AUDs. Moreover, to examine the quality and validity of TLFB as an outcome measure.	There were no significant differences between the experimental (eHealth) and the control groups regarding TLFB measures, but the experimental group presented significantly lower PEth results at 2 and 3 months. TLFB reports and eHealth data were relatively concurring for participants for whom the goal was controlled drinking but showed considerable discrepancies for those whose goal was complete abstinence.
McKay et al. (2021)	Determine whether adding TMC, A-CHESS, or an integrated combination of both interventions to IOPs improves outcomes for AUD. Additionally, to examine if TMC and A-CHESS differ and whether the combination of both is superior to the individual interventions	The study demonstrated that TMC and A-CHESS improved alcohol use outcomes by approximately 50 % over 12 months. Despite these positive effects presenting a deterioration in the following 6 months for TMC and A-CHESS, the same was not verified when there was a combination of both (TMC and A-CHESS). The combined intervention was not more effective than either TMC or A-CHESS alone.

the present review to assess the risk of bias in randomized controlled trials. The Joanna Briggs Institute JBI Critical Appraisal Checklist for Quasi-Experimental Studies was the tool used for the quasi-experimental studies.

When assessing the risk of bias, limitations were found in the methodological details regarding the five studies included in the present review, which were shown to be incomplete or insufficiently detailed. However, it can be seen (see Table 5) that there is a low risk of bias regarding the Random sequence generation in three studies (Gustafson et al., 2014; McKay et al., 2021; Mellentin et al., 2019), except for the study of Hamalainen et al. (2020) which demonstrated a high risk of bias. Regarding Allocation concealment, an unclear risk of bias was obtained in all studies evaluated (Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; Mellentin et al., 2019). Regarding the Blinding of participants and personnel and the Blinding of outcome assessment, the risk of bias was varied, highlighting an unclear risk of bias for the Blinding of outcome assessment in two studies (Hamalainen et al., 2020; Mellentin et al., 2019). In the Incomplete outcome data, three studies demonstrated a low risk of bias (Gustafson et al., 2014; McKay et al., 2021; Mellentin et al., 2019), while the other showed an unclear risk of bias (Hamalainen et al., 2020). For Selective reporting, the four randomized studies showed a low risk of bias (Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; Mellentin et al., 2019).

On the other hand, in the quasi-experimental study included (You et al., 2017) there was no control group. However, in the same study, it is clear which is the 'cause' and which is the 'effect' and there were no differences between the participants included, which points to a low risk of bias. The same study also showed no differences in the groups regarding treatment, also pointing to a low risk of bias. The low risk of bias was also verified through several measurements of the outcomes at various stages of the intervention (see Table 6).

Two reviewers discussed the final evaluation to reach a consensus regarding the discrepancies obtained (ER; JL). Whenever consensus could not be reached, a third reviewer (TC) was used.

4. Discussion

The main goal of the present systematic review was to synthesize the current scientific knowledge on relapse prevention/addiction treatment smartphone applications as a form of continuing care to better understand if they can be an effective alternative to traditional aftercare. Even though there have been many studies looking into the effectiveness of smartphone applications with therapeutic value, most have been focused on their use as an alternative to treatment and not so much as a form of continuing care. Therefore, few studies met the criteria and were included in the review.

4.1. Does the use of relapse prevention/addiction treatment smartphone applications after treatment lead to better recovery outcomes?

Out of the five studies included in the present review (Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; Mellentin et al., 2019; You et al., 2017), four of them compared the use of a smartphone application intervention to aftercare as usual (AAU) (Gustafson et al., 2014; Hamalainen et al., 2020; McKay et al., 2021; Mellentin et al., 2019), with only two studies reporting significant differences (Gustafson et al., 2014; McKay et al., 2021). In both these studies, the experimental group received some form of smartphone intervention as an addition to AAU, with both reporting better alcohol use outcomes.

On one hand, Gustafson et al. (2014) demonstrated that patients receiving treatment as usual paired with A-CHESS for 8 months, plus 4 months of follow-up while receiving only TAU reported significantly fewer risky drinking days both at the end of treatment (after 8 months) and after 4 months of follow-up when comparing to the control group – who received only 12 months of treatment as usual. On another hand, McKay et al. (2021) reported that patients receiving either TMC, A-CHESS, or a mix of the two (TMC and A-CHESS), demonstrated a lower frequency of heavy drinking days than patients receiving TAU.

As for the other two studies comparing smartphone-based intervention to TAU no significant differences were found in either the drinking

Table 5
Risk-of-bias assessment of the randomized controlled trials.

Author (year)	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Gustafson et al. (2014)	–	?	+	+	–	–	?
Mellentin et al. (2019)	–	?	–	?	–	–	?
Hamalainen et al. (2020)	+	?	?	?	?	–	?
McKay et al. (2021)	–	?	–	+	–	–	?

Note. – indicates low risk of bias; + indicates high risk of bias; ? indicates an unclear risk of bias.

Table 6
Quasi-experimental studies (Joanna Briggs Institute tool).

Author (year)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
You et al. (2017)	Y	Y	Y	N	Y	Y	Y	Y	Y

Note. Y indicates yes; N indicates no; ? indicates unclear; NA indicates not applicable.

or craving outcomes as measured by the alcohol timeline follow-back (TLFB; Hamalainen et al., 2020; Mellentin et al., 2019). Despite McKay and colleagues reporting the validity of TLFB data using a biological measure of heavy drinking that confirmed its results [namely, disialo carbohydrate-deficient transferrin (%dCDT)], Hamalainen et al. (2020), reflected on the quality and validity of TLFB in general for measuring an effect. They studied the Previct Alcohol® eHealth system and reported that although differences were not identified through TLFB measures, the experimental group presented significantly lower PEth results (level of phosphatidyl ethanol in the blood) at both 2 and 3 months. The authors point out that the discrepancy between the two measures puts into question the validity of TLFB as an adequate measure of alcohol use, given that there is evidence of significant under-reporting of TLFB in opposition to biomarkers and physical measurements. While recognizing that under-reporting of TLFB doesn't pose a problem for clinical trials because the tendency can be observed in both the treatment and control groups, the authors did alert to the need to be careful in measuring an effect with the use of TLFB measures only. They mention a study by Alessi and colleagues where 92 % of patients in outpatient care drank during treatment, with <50 % reporting drinking with TLFB (as mentioned in Hamalainen et al., 2020). In this line of thought, one could understand the importance of validating the TLFB data with biological measures - like McKay and colleagues reported -, at the same time that one could reflect on another study present in this review which outlined no results. That is the case of the study by Mellentin et al. (2019) - the only other study that didn't find significant differences between the experimental and control groups (CET group and CET app vs AAU) – where only TLFB measures were used.

As described above, the results from the studies included in the review are, in some regards, contradictory. This was to be expected considering the low number of studies and the high heterogeneity of variables such as the characteristics of the smartphone application (e.g., access, features) and the characteristics of what is being called AAU. Nonetheless, half of the studies that used a control group found significant differences in some type of alcohol use measure (e.g., TLFB or PEth results), the results suggest that the use of relapse prevention/addiction treatment smartphone applications following treatment for alcohol use disorder can lead to better recovery outcomes.

It is important to do more research not only concerning the effectiveness of smartphone applications as a continuing care alternative but also into possible moderating variables. Motivation and treatment adherence, for example, may be particularly important to consider when studying the effectiveness (and implementation) of these types of interventions. A systematic and meta-analytic review conducted by Linardon and Fuller-Tyszkiewicz (2020) indicated that study attrition and low adherence are common problems when exploring smartphone application interventions using randomized-controlled trials (RCTs). In their work, the authors reported that adherence to smartphone interventions was suboptimal, highlighting that low engagement and usage are common problems for many mobile apps. In opposition, increasing engagement and adherence is associated with greater reductions in mental health problems, which is in line with the findings of You and colleagues in studying the benefits of the SoberDiary app (You et al., 2017). While being the only study not using RCTs in the present review, they've also reported that participants who were highly adherent presented fewer drinking days and drinks consumed per week, as well as a higher cumulative number of abstinence days and abstinence rates. Moreover, they reported better results in other relevant clinical outcomes (i.e., anxiety, and quality of life) leading to the reflection on how effective mobile apps can be if we address the reported challenges of adherence.

4.2. Relapse prevention/addiction treatment smartphones applications vs. other forms of aftercare

Only one of the studies included in the review used an active control group, comparing the use of a relapse prevention/addiction treatment smartphone application to a specific form of aftercare. Mellentin et al. (2019) compared a Cue Exposure Therapy application (CET app) to both AAU and a Cue Exposure Therapy traditional group. While they found no significant differences between the experimental (CET group and CET app) and control groups, they also did not find any significant differences between the experimental groups themselves. These results indicate that CET delivered through a smartphone application was no less effective than CET delivered through the more traditional medium. As such, it is likely that the lack of significant improvements when compared with AAU, is due to the content of the therapy and not the form of delivery. This would be in line with results from a recent meta-analysis (Linardon & Fuller-Tyszkiewicz, 2020) that looked into the efficacy of app-supported smartphone interventions for mental health problems in general. Linardon and Fuller-Tyszkiewicz (2020) found that smartphone interventions did not differ significantly from face-to-face or computerized interventions.

Even though no active control group was used in the study of McKay et al. (2021), the type of study design enabled comparisons between three types of smartphone-based aftercare - TMC, ACHESS, and TMC + ACHESS – and AAU. Their aim was understanding the impact of combining both interventions as a form of continuing care for intense outpatient treatments. Despite their conclusions not matching the hypothesis that both treatments would complement one another and produce better outcomes than the interventions alone, their work suggests that using smartphone technology for personalized continuing care support is more effective than TAU.

Nevertheless, since all other included studies used a passive control

group (AAU; Gustafson et al., 2014; Hamalainen et al., 2020; Mellentin et al., 2019) or no control group at all (You et al., 2017), it was not possible to fully evaluate the relative effectiveness of relapse prevention/addiction treatment smartphone applications when compared to other forms of aftercare. Furthermore, since the studies comparing smartphone applications to AAU, used this last one as passive control, it's equally not possible to compare their separate effectiveness. Future studies should address this gap in the literature by using both passive and active control groups and providing a more detailed description of what is being considered as AAU.

4.3. Limitations

The results of the present systematic review need to be interpreted considering its limitations. As previously mentioned, the number of studies fulfilling all the chosen criteria was very low. This leads to high heterogeneity not only among relevant variables (e.g., characteristics of the smartphone applications) but also in terms of results, making it impossible to reach conclusive answers to the proposed research questions. Additionally, the high heterogeneity invalidated the possibility of conducting a quantitative analysis of the studies (i.e., meta-analysis).

Given that all the included studies focused on alcohol use disorders and alcohol dependence, it was not possible to investigate the effectiveness of these types of interventions in other substance use disorders, as it was our original intent. With only one study using an active control group, it was similarly impossible to analyse the relative effectiveness of smartphone application interventions when compared to specific types of continuing care modalities.

5. Conclusion

While they should be interpreted with consideration for the presented limitations, the results indicate that relapse prevention/addiction treatment smartphone applications lead to better recovery outcomes and may be an effective continuing care alternative. Divergent results appear to be explained by the content of the intervention and not by its modality. Future studies into the effectiveness of these types of interventions should take this into account and use not only passive but also active control groups. For example, it would be interesting to compare app-supported smartphone interventions to their equivalent in traditional aftercare (i.e., using the same theoretical background and similar techniques) instead of only aftercare as usual. Moreover, to evaluate their potential as a real continuing care alternative instead of only an adjunct intervention, relapse prevention/addiction treatment smartphone applications need to be studied as such. Further research should consider analysing the effectiveness of these interventions independently from aftercare as usual.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data availability

Supplementary material (Database Study Selection) - Effectiveness of Smartphone Interventions as Continuing Care for Substance Use Disorders: A Systematic Review available at https://data.mendeley.com/datasets/mh9283tgxh/1.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2023.103898.

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