Evaluating the Impact of eHealth Tools as Add-ons to Face-to-Face Treatment for Adults with Alcohol and Substance Use Disorders: An overview.

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Abstract

Background: A large number of applications (apps) is available for individuals with addiction problems, the majority of which is available freely and not subject to research.

Objective: This paper studies the additional benefit and outcome in alcohol and substance use disorder (AUD, SUD), when professional managed apps are added to face-to-face treatment.

Methods: A literature search on randomized controlled trials (RCT) was carried out, where treatment as usual (TAU) was compared to TAU supplemented by an app. TAU was defined as the type of regular treatment at the respective treatment site. Between 2014 and 2023 sixteen RCTs added an app to at least one randomized group in adults suffering AUD and SUD.

Results: There was a broad variation with respect to the range of disease severity and the presence of co-morbidities. Active app elements were presentation of information, monitoring, motivational tools, psychotherapeutic tools, crisis intervention and communication with professionals. Interventions lasted from 1 to 12 months, follow-ups were executed in 9 studies. Results speak in favor of reduction of substance use in terms of days of use and / or days of heavy use by introduction of an app. A time-related pattern arose with early improvement in most studies, levelling off of the effects after several months, but with good results for individuals who stayed in treatment for about one year.

Conclusions: Overall, hybrid approaches in addiction treatment may cost-efficiently enhance effectiveness of treatment and reach individuals in remote areas. They should be integrated into professional care, but not replace it. Clinical Trial: n/a

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Methods: A literature search on randomized controlled trials (RCT) was carried out, where treatment as usual (TAU) was compared to TAU supplemented by an app. TAU was defined as the type of regular treatment at the respective treatment site. Between 2014 and 2023 sixteen RCTs added an app to at least one randomized group in adults suffering AUD and SUD.
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Conclusion: Overall, hybrid approaches in addiction treatment may cost-efficiently enhance effectiveness of treatment and reach individuals in remote areas. They should be integrated into professional care, but not replace it.

Introduction

There is a growing body of research examining the effectiveness and impact of smartphone apps for various psychiatric diseases including substance use disorders. As of August 2019, a search of iTunes and Google Play indicated that over 45,000 mHealth apps targeting substance use were available [1]. Recent reviews including randomized controlled trials (RCTs) or peer-reviewed studies, e.g. 17 versus 18 publications targeting stand-alone apps in substance use (SUD), yield low-strength evidence and small effect sizes respectively [2,3]. Authors state that effects were clearly smaller than those of in-person therapy. Also, long-term studies of more that 12 months are missing.

Overall, apps can provide valuable support and resources for individuals with addiction problems such as psychoeducation, self-help tools, coping strategies, and support networks. Some studies point out that apps can show effectiveness at lower costs compared to therapeutic contacts [4,1]. However, it is important to note that addiction is a complex condition that requires multifaceted, comprehensive and evidence-based interventions delivered by healthcare professionals with clinical oversight. These professionals can provide personalized care which includes medication and psychotherapy, considering various social risk factors and the complex interplay of addiction and co-occurring mental and physical disorders, as well as incorporate safety and risk management measures of ehealth. As yet, apps may complement evidence-based interventions but not substitute the total of a comprehensive treatment plan [5]. Thus, our goal was to shed more light on possible advantages of adding professionally managed smartphone applications to evidence-based treatment. Apps had to be integrated parts of the treatment plan and fulfill safety requirements.

Moreover, we tried to characterize the particularities of these applications, such as information and advice, improvement of treatment engagement, support to stop or moderate consumption and personalization of support as well as the advantages of the hybrid model. This has not been undertaken as yet. Thereby, we focused on alcohol and substance use disorders (AUD and SUD), which are often studied together, thereby excluding tobacco and non-substance related addictions.

Methods

We conducted a systematic literature search which focused on randomized controlled trials (RCTs) listed in PubMed/Medline and PsycNET, which includes PsycInfo and PsycArticles.

Search Strategy

On July 10, 2023, the electronic databases MEDLINE and PsycNET, which includes PsycInfo and PsycLit, were searched for empirical studies on the integration of applications into treatment for substance use disorders. The following keywords were used: ((ehealth OR mhealth) AND (application OR app)) AND (("mobile phone" OR "smartphone")) AND (("substance use" OR "substance abuse" OR alcohol OR addiction)). The search yielded 297 publications, including 40 randomized controlled trials (RCTs), with the earliest studies dating back to 2013. This is in line with the numbers on smartphone ownership worldwide, with a median of 45% in emerging countries in 2013, rising to 54% in 2015 as well as a median of 87% in advanced countries [6].

Screen for eligibility

Titles and abstracts of the initial search results were screened. Eligibility criteria included:
(1) randomized controlled trial approved by the respective ethics committee,
(2) adult participants over the age of 18,
(3) diagnosis of AUD, SUD, or dual disorder (AUD and/or SUD with another psychiatric disorder),
(4) TAU for all study participants,
(5) the addition of an electronic tool in at least one randomized group,
(6) in cases where a research group had published multiple articles on the same data set, either the original study or the study with the largest number of participants was selected, while the remaining articles were discarded.

Data extraction and summary

Data from the selected studies were tabulated with the following information: author and publication year, country, target population, number of subjects, sociodemographic data, type of control intervention, type of add-on intervention, duration of study and follow-up (if present), outcome measures, results, and possible incentives.

Results

Study selection

The initial search identified 297 publications, of which 40 were clinical or randomized trials. Full texts of these 40 trials were downloaded. After applying the eligibility criteria, 22 papers were retained, the oldest dating from 2014. The most common reasons for study exclusion were the presence of control groups without any intervention, publication of secondary analyses or study protocols, a focus on prevention rather than treatment, or an emphasis on feasibility and user satisfaction. One study [7] was excluded due to unclear fulfillment of add-on criteria. Additionally, 6 of the 22 studies were excluded as they referred to a patient group already represented in other included publications [8-14]. Consequently, 16 studies remained for further analysis.

Characteristics of included studies and study participants

The 16 remaining RCTs on AUD and/or SUD were published between 2014 (earlist study meeting inclusion criteria) and June 2023. For information on studies see table 1.
As this review focuses on apps as a supplement, we refer to any given standard comparison treatment at each site as TAU. Thus, TAU, as defined here, represents the various regular treatment programs at different centers, which are not directly comparable.
Several researchers did not mention whether or not co-morbidities were present [15-20], whereas others excluded schizophrenia and bipolar disorder [21] or schizophrenia and cognitive impairment [22]. Lucht et al. [23] excluded patients in whom non-adherence was expected. Overall, the range of disease severity varied widely, from AUD without any comorbidity and excellent motivation on the one hand to SUD in individuals experiencing homelessness and multiple health and social problems on the other.

Whereas the majority of participants was recruited from outpatient clinics, inclusion was realized at the end of a residential treatment program [4] in one study and

following an inpatient stay for alcohol dependence in two others [24,23]. Except for 20% of participants in the study by Liang et al. [16] all participants were outpatients. Face-to-face contact with a member of the treatment team was provided for every participant. Although two studies [22,24] did not explicitly mention this, it is known that the respective healthcare systems in Denmark and Germany typically offer easily accessible and adequate primary care for AUD and SUD. Therapeutic groups sessions were part of the regular treatment program for all participants in five studies [25,18,26-28].

Regarding the primary outcome, one study aimed for abstinence and time to first drink [24], while others documented abstinence days [23,29,21], cumulative abstinence days [26] and negative drug or alcohol tests [18,20]. The remaining researchers recorded days of consumption, drinking days, heavy drinking days, and standard drinks per drinking day. Thus, all studies targeted either abstinence or reduction of use.

Study	Substance/Diagnosis	Patients (n)	Sociodemographics	Duration	Incentives
Aharonovich et al 2018, US	alcohol and non-injectable drugs in HIV+ patients primarily crack 91.5% exclusion of psychosis, gross cognitive impairement, use of injection drugs past 6 m	n=47	age 51 yrs 77% male 79% African American 17% Hispanic 81% high school 28% stable relationship 94% unemployed	2 m	HIV treatment smart phone (or 100 USD gift card in MI) distributed to MI group at end of study
Campbell et al 2014, US	drugs +/- alcohol	n=507 from 10 sites	age 35 yrs 62% male	3 m f/u 3, 6 m	draw vouchers which yield congratulatory messages (e.g. “good job”) or are exchangeable for prizes of mostly modest value ($1)
Farren et al 2020, Ireland	alcohol 41% severe psychiatric comorbidites	n=111 after 30 d rehabilitation program	age 46 yrs 52% male 48% partner, family 100% high school or above 14% unemployed	6 m f/u 3, 6 m	--
Graser et al 2021, Switzerland	alcohol 52% comorbidities	n=240 after 12 w inpatient rehabilitation prerequisites: aiming for long-term abstinence, no consumption during rehabilitaion	age 50 yrs 69% male 55% partner, family 100% high school or above 38% unemployed	6 m	--
Gustafson et al 2014, US	alcohol 47% psychiatric comorbidities	n=349 after residential treatment	age 38 yrs 61 % male 80 % white 46% living with partner/family 72% high school 79 % unemployed	8 m f/u 4 m	--
Hammond et al 2021, US	alcohol in drug users	n=61 from 3 clinics	age 40 yrs 61% male 87% white 67% living with partner/family 100% high school or above 41% homemaker, unemployed, disabled	3 m	money, max 600 USD, in population with 70% household income of less than 50'000 USD
Hasin et al 2022, US	alcohol in HIV+ patients comorbidities present	n=114 from primary care clinic for infectious diseases	age 48 years 58% male 75% African American 38% high school or above no information on partnership + employment	2 m f/u 3, 6, 12 m	study smart phone or equivalent value in gift cards
Heitmann et al 2021, Netherlands	alcohol 78% cannabis 22%	n=169	age 43 yrs 73% male 66% partnership 95% high school or above 68% employed	minimum 7 weeks f/u 6, 12 m	--
Liang et al 2018, China	SUD primary drug: heroine in 80%, amphetamine type stimulants in 15%	n=75 80% outpatients from methadone maintenance clinics and social workers' networks	age 42 years 72% male 100% Han Chinese 44% married 59% high school or above 60% employed 7% incarcerated prior to study	1 m	total amount possible: participants in control group: 230 yuan (about 36 USD) participants in the intervention group 398 yuan (about 63 USD)

Lucht et al 2021, Germany	alcohol exclusion criterion: expected non-adherence	n=462 after inpatient treatment	age 45 yrs 77 % male 46% couple or widowed no information on schooling 82% unemployed	12 m interviews at 3, 6, 9, 12 m	small remuneration per interview, baseline 30 €, then 10 €
Mc Kay et al 2022, US	alcohol comorbidities cocaine, anxiety, major depression exclusion of psychotic disorder + dementia	n=262 treatment prior to study < 6 w	age 47 yrs 71% male 81% African American 33% ever married 71% high school no information on employment	12 m calls decreased in frequency m 1: 4x, m 2-4: 2x each, m 5-7: 1x each, m 8-12: every other m assessments m 3, 6, 9, 12 thereafter 6 m f/u	--
Mellentin et al 2019, Denmark	alcohol exclusion of psychotic illness, severe cognitive impairment	n=164 after 3-m primary outpatient treatment blinded	age 47 yrs 78 % male no information on partnership 67 % vocational training/ bachelor incl. high school 45% temporarily unemployed	2 m f/u 6	--
Paquette et al 2023, US	SUD + alcohol 2 or more SUD in 77% 2 or more psychiatric co-morbidities, non-SUD in 57%	n=206 intensified outpatient treatment (IOP): 12 weeks group- + individual sessions 3-4 h/ x3 per w	age 40 yrs 66% male 54% white high school or above "average" low income no information on partnership + employment	3 m f/u 1, 3, 6, 12 m	apple iPhone 6
Scott et al 2020, US	SUD exclusion of cognitive impairment, schizophrenia or bipolar disorder	n=401 from residential home or detoxication therapy, intensive or regular outpatient treatment	age 44 yrs 61% male 70% African American 67% high school or above no information on partnership + employment	6 m	Samung Galaxy S5,S6,S7 for study use up to $280 for interviews and visits
Thompson et al 2020, US	SUD	n=60 from crisis shelter	age 19 yrs 75% male 65% African American 25% high school or above 75% unemployed 40% history of abuse 48% history of foster care 53% ever incarcerated 80% had lived on street before	1 m	up to $ 180 as gift cards intervention group, at end of study 100 USD or smartphone for all
Tsui et al 2021, US	opiates	n=78	age 42 yrs 72% male 62% White 35% ever partnership 83% high school or above 22% employed 40% homeless	3 m f/u 3 m	Smartphone

LEGEND
AA = alcoholics anomymous
ACHESS = addiction comprehensive health enhancement support system
AUD : alcohol use disorders
AUDIT : alcohol use disorders Identification test
age = mean age
EMI = ecological momentary intervention
f/u = follow-up
IOP = intensified outpatient treatment
LETS ACT = life enhancement for substance use
m = month (s)

BAI = Beck Anxiety Inventory
BDI = Beck's Depression Inventory
BMI = brief motivational interviewing
CBT= cognitive behavioural therapy
CET = cue exposure therapy
DD = drinking days
EMA = ecological momentary assessment
STD = sexually transmitted disease
SUD = substance use disorder
RCT = randomized controled trial
TAU = treatment as usual, here: usually in the respective center withouth App
TLFB = timeline follow back
TMC = telefone monitoring and counse
w =

Table 1: Randomized controlled studies, authors, year, county, number of patients, sociodemogra
duration, incentives if applicable

The Apps under study

The Apps used in these studies were smartphone applications designed for documentation/ self-monitoring and messaging. Most of these Apps were based on multiple modules and incorporated elements of cognitive behavioral therapy, motivational interviewing, and psychoeducation.

The main features of the Apps under study included:

1. Information

Four apps included information modules on addiction, treatment, care, and support offers [4,21,20,27]. It was unclear whether similar information was provided in the other studies. Given that most apps incorporated elements of CBT, the provision of information might have been considered an implicit component of the intervention.

2. Monitoring /documentation

All apps primarily monitored or facilitated self-monitoring of consumption by recording parameters such as abstinence, drinking days (DD), heavy drinking days, quantity consumed, severity of dependence, urine or blood tests, blood alcohol concentration via breathalyzer, and therapy observed by video. Thus progress was tracked. All but two studies [20,18] explicitly or implicitly – via use of emergency tools – assessed craving. Additional documentation covered psychiatric symptoms [16,28,29], consequences of drinking [27], general risk situations [4,16,21], sexual behavior [15,17,29], and money spent on drugs [15]. Adherence to treatment was documented in all studies, though only indirectly in one [24]. App usage, including the frequency and duration of specific tools, was recorded by several authors [4,15-18,29]. Positive attitudes were assessed by measuring protective factors [4,21], engagement and progress in treatment [28], coping skills [22], and personal goals [15,29]. Quality measures, such as quality of life, satisfaction with the app, its usefulness, feasibility, and usability, were evaluated by various studies [15,16,18,27].

3. Support via communication with healthcare providers

Relapse prevention tools: The majority of research groups provided support during crises. Three apps included an emergency button [21,27,28], and five offered the option to communicate with a caregiver [4,21,22,24,27] sometimes incorporating a geolocation feature [21,4]. Two apps directed participants to emergency hotlines, self-help groups, or forums [4,21]. Additionally, two groups proactively contacted patients if they remained silent for an extended period [23,27].

Motivational tools : These were included in nearly all studies. They consisted of simple reminders [20,22,18], motivational or supportive messages [4,21,23,27,15,26], and personalized messages [17,26,16,29]. In addition to supportive messages, one study [15] provided videos [15], and another offered skill suggestions on a daily basis [17]. One group introduced reward-based behavior

modification [26], while yet another study utilized group meeting participants as mutual motivators [28].

4. Specific psychotherapeutic tools

All but one study included psychotherapeutic tools primarily based on CBT [4,21,27,15,26,28,16,22,24,29], or motivational interviewing [15,17,19,29]. Eight groups provided specific and personalized strategies [4,21,23,15,26,28,22,27]. The app ACHESS also procured games and peer support [4,21,27]. Relaxation techniques were conveyed in two apps [21,27], and one app incorporated music and physical exercise [21].

5. Specialized tools

Three studies included specialized tools: one intervention exclusively utilized video observation [20], another incorporated self-testing tools for alcohol and drugs with contingency management [18], and the third offered internet-based attentional bias modification [19]. Notably, the third study was an exception as it combined an internet gamification tool with assessments conducted via smartphone.

All of the above features aimed to enhance treatment adherence, provide real-time support, and facilitate behavior change. More details are displayed in table 2.

Outcomes

In 12 of the 16 studies at least one intervention group showed superior outcomes with regard to the primary outcome criteria (see Table 2) which were any drug and alcohol use, abstinence or consumption days, units consumed per consumption day, heavy consumption days. These improvements were mostly measured via self-report. An equal number of studies targeted alcohol users [4,24,23,3,27], and drug users [15,17,21,25] as well as use of both [15,19,18,28].Outcomes were partially comparable between intervention and control groups in 6 studies [16,22,26-29] where there was a similar change of consumption patterns over time. Two of these studies reported a deterioration in all groups [22,27].
McKay et al. [27] suggested that ceiling effects might explain the deterioration observed. This seems to be the case as well in Mellentin et al.'s study [22], where patients were included after completing a 3-month inpatient program, during which they had achieved high rates of 80% sensible drinking and 70% abstinence. These parameters worsened during the reported study period. The third RCT which reported deterioration was by Tsui et al. [20]. Their intervention group consisted of opiate users from a challenging socioeconomic background, and the intervention was predominantly technical, namely video documentation of treatment. Outcome was even worse in the intervention group, however non-significantly so.

Regarding secondary outcomes, psychopathological information was collected in two studies and improvement stated [19,26] in the TAU and the intervention group. Moreover, Graser et al. [24] indicate higher self-efficacy in the intervention groups and Heitman et al. [19] a decrease in craving. The latter was not found by Mellentin et al. [22] who also assessed coping skills which were used more often by the intervention group. Negative consequences of consumption were protocolled by Gustafson [4] without group differences.

An unexpected outcome was reported by Paquette et al. [28] who stated the best results at 12 months for LETS ACT as opposed to their hypothesis that the smartphone enhanced intervention LETS ACT would be superior.

Duration of study, follow-up interval and outcome

Studies lasted from 1 month to 12 months, follow-up visits were performed by 9 groups [4,17,20,15,16,19,21,22,24-26,28,27,29] and amounted to 1 to 4 visits during 3 to 12 months.

Studies which lasted for 1 to 6 months reported a decrease of consumption in the intervention groups or even in TAU and intervention groups [17,20,15,16,19,21,22,24-26,28,29] – with one exception [22]. However, groups conducting follow-ups reported that the initial improvement effect was lost after 6 to 12 months [25,29] when consumption reached the initial or an even higher level [28]. Heitmann et al. [19] found stability up to one year posttreatment. Mellentin et al. [22] and McKay et al. [27] are in line with the aforementioned results, because most likely ceiling effects had been reached. The best outcomes in the intervention groups were detected in three studies with an extended treatment period of 8 to 12 months [4,23,27].

Contact with therapists and outcome

Studies reporting favorable or partially favorable outcomes demonstrated that, in addition to app utilization, there was an increased frequency or regularity of personal contact and the incorporation of personalized care elements. These included face-to-face or telephone interactions, tailored support when necessary, and the provision of opportunities for

Study	**Intervention(s)**	**Main app tools**	**Primary (1) / secondary outcome (2)**	**Results**
Aharonovich et al 2017, US	2 groups: - Interviewing (MI) + HealthCall-S - MI	*Monitoring:* consumption of alcohol + drugs, money spent, engagement, satisfaction, personal goal attainment, medication adherence, safe sex, stress, wellness, QoL *Motivational tools*: personalized feed-back, encouraging messages, videos *Psychotherapeutic tools*: discussion of personal goals	(1) primary drug days used, quantity of drug used = money spent per day, DD, DpDD - TLFB and interviews for alcohol + drug use, validated by breathalyzer and urine (2) engagement: proportion of days used out of the total number of possible days, satisfaction with app, completion	(1) sign. more decrease in drug use, money spent, DD and DpDD: MI+HealthCall-S > MI MI only group developped in same direction (2) 95% median rate of App use; satisfaction 4.5 / 5 95% completion in both groups 91% in MI+HealthCall-S retained study phone
Campbell et al 2014, US	2 groups: - Therapeutic Education System (TES): interactive modules + quizzes on computer + TAU - TAU TAU: individual counselling, groups counselling 2-6x/w	*Information* *Monitoring*: abstinence, self-report time to drop-out from treatment, urine tests *Motivational tools*: contingent motivational incentives for abstinence and therapy adherence *Psychotherapeutic tools*: Contingeny management and CBT relapse prevention, i.e. skills teaching via video clip, psychosocial functioning, prevention of STD	(1) abstinence + retention in treatment drug use via TLFB self report and urine every half-week	TES sign. increased the odds for abstinence (OR 1.62), effect no longer sign. at f/u abstinence at study entry was best predictor for outcome at end of study and at f/u (OR 5.73) adherence in TES about 50% vs 40% in TAU similar number of sessions in TAU equal development in both groups for all parameters tested
Farren et al 2020, Ireland	2 groups: - decreasing frequency App UcontrolDrink + TAU	*Montoring:* drinking, recovery *Motivational tools*: supportive SM 2x/d, reward-based behavior modification *Relapse prevention:*	(1) DD, high DD, DpDD, cumulative abstinence days (2) AASES=Alcohol Abstinence Self-	(1) DD decreased in both groups: App > TAU: sign. effects for time and intervention, intervention × time n.s. heavy DD decreased in both

	- TAU TAU: 90 min/ w therapist led groups, based on CBT + 60 min lectures + AA	personalized craving intervention *Psychotherapeutic tools*: 12 CBT sessions, personalized anti-craving intervention, gamification as reward-based behavioural modification technique	Efficacy Scale; BDI, BAI, OCDS, AUDIT and further questionnaires	groups: App > TAU: sign. effect for time, fixed for intervention n.s., sign. effect for intervention × time DpDD decreased in both groups, but greater absolute number of DpDD in App, sign. effect for time, intervention n.s., intervention × time n.s. Cumulative abstinence days: App > TAU sign. effect for time, intervention n.s., time x intervention n.s. (2) scores of AUDIT, BDI, AASES total improved in both groups higher BAI in App group score over time further findings: 58% completers including f/u 6 m high comorbidity and high employment rate
Graser et al 2021, Switzerland	4 groups: - high-frequency (x 9) telephone contact (TEL) - low-frequeny (x 2) TEL - text messages (TEX) (x 9) - TAU	*Monitoring*: alcohol use, time to relapse *Motivational tools*: calls if needed *Relapse prevention*: emergency calls *Psychotherapeutic tools*: support + CBT, e.g. identify high risk situations in TEL with known therapist TEX: standardized monitoring questions and feed-back messages	(1) abstinence based on self-reports via interviews, questionnaires time to first alcohol use as number of days after treatment discharge (2) alcohol related self efficacy	(1) abstinence rates: high-frequency TEL 57% > low frequency TEL 48% > TEX 46% > TAU 36% (significance: high TEL vs TAU) trend towards longer time to relapse in high-frequency TEL overall: 38% relapsed in m 1, 73% relapsed up to m 3 87% analyzed post 6 m of study loss to f/u comparable between groups (2) sign. higher self-efficacy at 6 m in high-frequency groups (TEL, TEX), low TEL comparable to TAU
Gustafson et al 2014, US	2 groups: - A-CHESS + TAU - TAU TAU = case management + group therapy based on CBT + AA	*Information* *Monitoring:* consumption, risk + protective factors, daily surveys for craving and affects with scale 0-10 *Motivational tools*: motivational messages *Relapse prevention*: contact with caregiver, forum *Psychotherapeutic tools*: specific coping strategies	(1) reduction of risky DD in 30 d, defined as > 4 vs. > 3 standard drinks (men vs. women) within 2 h interval (2) abstinence, negative consequences of drinking, i.e. agression, financial problem, accident	(1) risky DD: sign. fewer in A-CHESS during intervention as well as at 4 and 12 m f/u post hoc analysis on relationship between number of risky drinking days and cumulative App use: the number of risky drinking days was significantly predicted by the number of pages viewed and days used (2) abstinence: higher odds in A-CHESS with more days of abstinence at 8 and 12 m (52% vs 40%) negative consequences of drinking: no significant differences
Hammond et al 2021, US	2 groups: - DynamiCare + TAU - TAU DynamiCare: contingency manage-ment with remote self-testing for alcohol (breath) and drugs (saliva), financial incentives if negative TAU = 70% group therapy 3x /w, 12 or 20 w; 30% court-ordered Drivers Alcohol Education program or other	*Monitoring:* alcohol + drug tests by breathalyzer or saliva tests duration of participation *Motivational tools*: reminders *Psychotherapeutic tools*: contingency management	(1) number of negative tests for alcohol + drugs, abstinence (2) duration of participation in d termination of study if more than 30 d missing in a row	(1) App: 92% vs. 95% negative tests for alcohol vs. drugs in users who stayed for ≥ 7 d - no data for TAU overall abstinence in App: 33% vs. 16%, rate fell from 35 to 28%, from 22 to 9% in TAU (2) assessment completion rates sign. greater in App: at the 1-, 2-, 3- and 4-m 41%, 45%, 45%, and 34% (41% overall) vs. 28%, 28%, 19%, and 16% (23% overall) App group had more days in baseline TAU but n.s. 72% of app group used it daily for at least 8 w 2 App groups: long use, mean 84 d, smaller short use group with durations from 0 to 23 days 92% rated the experience with the app extremely of mostly positive
Hasin et al	3 groups: - HealthCall + MI	*Monitoring*: self-monitoring of behavior, mood, safe sex, goal	(1) DpDD and DD during 30 d	(1) DpDD at 6 m HealthCall+TAU < HealthCall+MI < TAU, n.s.

2022, US	- HealthCall + TAU - TAU HealthCall = daily self-monitoring of drinking and other health behaviors for 60 d TAU = evidence based treatment	attainment, breathalyzer, HIV medication adherence *Motivational tools*: personalized feed-back *Psychotherapeutic tools*: MI and booster sessions at 30 d and 60 d, TAU with EBM drinking reduction techniques	intervals via TLFB	at 12 m 29% more reduction in DpDD in HealthCall + TAU compared to TAU only reduction of frequency in all groups (almost to half), stable up to 12 m further outcomes: retention: of 114 participants, 98 (86%) completed the study, no difference between groups use of App 89% in HealthCall+MI and 88% in HealthCall+TAU
Heitmann et al 2021, Netherlands	2 groups, multicenter: - intervention + TAU - sham + TAU TAU = based on MI + 6-12.5 h CBT, according to Dutch guidelines	*Monitoring*: substance use, craving, depression, anxiety, stress *Measurement of motivation / engagement* : odd one out test *Psychotherapeutic tools*: Internet based attentional bias modification, recommendation to train at times when craving is strongest	(1) frequency of use 30 d, quantity for alcohol only in DpDD craving with OCDS=obsessive compulsive drinking scale (2) physical and psychological complaints via DASS=depression, anxiety, stress scale, a self report measure	(1) sign. decrease in frequency of use from baseline to posttest in all groups, no change from post-test to f/u 6 m, and from f/u 6 to f/u 12 m, time x condition n.s. sign. decrease in overall craving baseline to posttest, sign. increase from posttest to f/u 6 m, f/u 6 to 12 m n.s., time x condition n.s. (2) sign. reduction of depression, anxiety, stress during intervention in both groups, sign. increase to f/u 6 m, stable between f/u 6 and 12 m at a level higher than baseline relapse: 38% in the ABM vs. 35% in controls, n.s. retention rate: 53% to end of study, 3.2 m until relapse, 38% abstinent; 40% f/u 12 m, 3.0 m until relapse, 35% abstinent
Liang et al 2018, China	2 groups: - SM + daily surveys via S-Health App + TAU (n=50) - educational SM + TAU (n=25) TAU = clinics, social workers	*Monitoring*: consumption, urine, psychiatric symptom, risk situations, addiction severity index, daily surveys for craving + affects on 10 point scale *Motivational tools:* personalized messages *Psychotherapeutic tools*: CBT based, related to craving, affect, triggers, coping strategies and social context	(1) recovery / abstinence feasibility	sign. less consumption days in intervention group (-1.5d/w) both groups consumed less, less likely to have positive urine tests, n.s. between 53% and 72% positive answers regarding feasibility and acceptance of the App intervention
Lucht et al 2021, Germany	2 groups, multicenter: - SM decreasing frequency + TAU - TAU	*Monitoring questions:* 1. Did you drink? 2. Do you need help? *Motivational tools*: supportive emails P*sychotherapeutic tools*: brief supportive calls by therapist if drinking=yes, if help needed or if patient does not answer monitoring messages / questions, calls within 24 h during work days	(1) alcohol consumption during mo 10-12 post randomization: heavy > non-heavy drinking > abstinence by FORM-90 interview (2) DD, drinks per day + DpDD	(1) SM vs TAU at 10-12 m: heavy drinking (22 vs 32%), OR 1.68 without difference: non-heavy drinking (33% vs 25%), abstinence (45% vs 42%) sign. more abstinence days in SM (2) no difference: longest abstinence period, number of DD, number of heavy DD, DpDD, drinks per day adherence sign. better in SM group (31% vs 22 % loss to f/u) no difference in service use
Mc Kay et al 2022, US	4 groups: - IOP + telephone monitoring and CBT based counseling (TMC) - IOP + smartphone (A-CHESS) - IOP + telephone + smartphone (ACHESS+TMC) - IOP only TAU=IOP: group counselling 9h/ w for 3 m, followed by continuing	*Information* in ACHESS *Monitoring*: drug use and drinking, heavy drinking days, consequences, QoL, questionnaires, urine toxicology *Motivational tools*: daily encouraging + supportive mg in ACHESS, risk + protective factors weekly *Relapse prevention*: panic botton, alerts to individual counselors if 7 d inactivity + subsequent reminders in ACHESS *Psychotherapeutic tools*: telephone arm: CBT based counseling, coping strategies +	(1) heavy DD m 1-12 (2) any drinking, any drug use, negative consequences of alcohol use, QoL	(1) heavy DD sign. higher in all study groups, about 50% during m 1-3, stable until f/u m 18 sign. higher decrease in TAU than in any other group, no difference between intervention groups m 1-12 (2) any drinking sign. higher in TAU than in TMC and TMC + ACHESS for m 1-12, difference n.s. for ACHESS no other differences regarding secondary variables adherence: TAU 75%, TMC 59%, ACHESS 62% , ACHESS + TMC 73%

	care 1x/ w for another 3 m	behaviors, encouragement of pro-recovery activities ACHESS: relaxation, games, peer support, selfhelp meetings		
Mellentin et al 2019, Denmark	3 groups: - Cue exposure therapy (CET) - fully automated CET - TAU TAU = 60 min/ w x 8	*Monitoring:* consumption *Motivational tool:* reminders *Relapse prevention*: call + meet therapist monday-friday *Psychotherapeutic tools*: exposure exercises 4 d/ w, craving-specific coping strategies + coping skills	(1) abstinence, DD, DpDD from TLFB (2) craving (VAS), urge specific coping skills questionnaire (USCSQ)	(1) abstinence decreased, increase in DD and DpDD in all groups, during intervention and f/u decrease in sensible drinking during intervention nonsign, sign to f/u nonsignificantly better results in CET: abstinencen + sensible drinking prior to study: whole sample had achieved 80% sensible drinking + 70% total abstinence during primary treatment, here: beginning relapse (2) both CET groups used coping skills questionnaire more often during intervention, effect lost at f/ u; no differences regarding craving
Paquette et al 2023, US	3 groups: - smartphone-enhanced (SE) LETS ACT (small groups) + IOP - LETS ACT + IOP - TAU = IOP SE LETS ACT included 6x 1h behavioral activation (BA) groups with 6 patients maximum	*Information in IOP* *Monitoring:* frequency of self-reported substance use days, urin *Motivational tools:* group, journal on activities *Psychotherapeutic tools*: identify, plan + implement value-based activities, plan + implement; problem-solving, post-treatment planning APP: tutorial, homework, library, calendar	(1) DD or consumption days via TLFB for 30 d (2) problem related to substance use via the SIP-AD = Short Inventory of Problem-Alcohol and Drugs (SIP-AD)	(1) sign. decrease in consumption days in all groups during 3 m increased again afterwards above the initial level until f/u 12 m sign. condition x time effect: decrease of consumption days until 6 m in LETS ACT, until 3 m in LETS ACT-SE, 1 m in TAU but probability of substance use: highest in LETS ACT 12 m f/u (2) sign. effect of time for substance-related problem, decrease until f/u 1 m, sustained in all groups until f/u 12 m 16% substance use days pre-, 6 post-treatement, 18% at 12 m f/u no effect of condition or time x condition n.s. best result for LETS ACT at 12 m -> behavioral activating app did not additionally improved outcome
Scott et al 2020, US	4 groups: - EMI (from A-CHESS) - EMA - EMI + EMA - TAU TAU = community based treatment accessible to all participants	*Information* *Monitoring*: in EMA: 5 assessments/d including risk situations, craving, protective factors; urine in all groups *Motivational tools*: in EMI+EMA: motivational messages *Relapse prevention*: in EMI emergency hotlines, treatment locators, links to free self-help, caregiver contact *Psychotherapeutic tools:* in EMI: relapse prevention model including affect management, healthy coping mechanism, activities such as relaxation, music, physical exercise	(1) abstinence days during a 90 d period (2) effects of recovery support with EMI or EMA or both on days of abstinence within previous 90 interval indirect effects of EMA via EMI utilization (relax, reach out to others, exercise…)	(1) increase of abstinence days in all groups: sign. but small increase of mean abstinence days from 60 to 65 d in 3 m interval, to 63 d at 6 m relative to the previous 90 d (2) sign. but small effect of EMI / EMI+EMA on additional increase of abstinence days over time, especially with consistent use EMI only: abstinence days means amounted to 58 to 66 to 66 days (0, 3, 6 m); no-EMI groups: 62 to 63 to 59 days (0, 3, 6 m) EMI use in EMI+EMA group > EMI group: 96% vs 92% of weeks with at least one EMI, this indicated high compliance proportion of weeks using EMIs and the frequency of listening to music via EMI) predicted 7.2% of the variance in days of abstinence
Thompson et al 2020, US	2 groups: - OnTrack + BMI - TAU	*Information* *Monitoring*: alcohol, marijuana, medicaton adherence, sexual risk behavior, sex-related substance-use *Motivational tools*: personalized feedback, positive reinforcement, daily tips for skills *Psychotherapeutic tools*: 3 x BMI	(1) alcohol use, marihuana use, sexual risk behavior: unprotected sex and sex-related substance use all via TLFB every 2 weeks (2) satisfaction, acceptability,	(1) sign. reduction in alcohol+marijuana consumption, unproteced sex, drugs used before sex after controlling for baseline, sign. lower odds for alcohol and unprotected sex (AOR=0.14; AOR=0.15) (2) very easy to use (100%), engaging (100%), made more aware drug and alcohol use

			perceived effectiveness of App via 24-item questionnaire	(100%), helped cut down all risk behavior (50-70%) participation 78% of all possible days = very high engagement
Tsui et al 2021, US	2 groups, 2 sites: - video-DOT (directly observed therapy) + TAU - TAU TAU included visits with nurse or care managers every 1 or 2 weeks	*Information* *Monitoring:* treatment recording via smartphone - video *Motivational tool / relapse prevention*: treatment reminder	(1) percentage of 12 weekly urine drug tests (UDT) negative for illicit opioids (2) engagement in treatment at week 12	50% negative urine samples in video-DOT vs 64% in TAU = less consumption in TAU, n.s. (0.07) 69% adherence to treatment at 3 m in video-DOT vs 82% in TAU + 41% vs 56% in TAU at 24 weeks = better engagement in TAU, n.s. (p=0.20) 31% of possible videos submitted, 56% phones not returned, 16% returned damaged

LEGEND
AA = alcoholics anomymous
ACHESS = addiction comprehensive health enhancement support system
AUD : alcohol use disorders
AUDIT : alcohol use disorders Identification test
age = mean age
BAI = Beck Anxiety Inventory
BDI = Beck's Depression Inventory
BMI = brief motivational interviewing
CBT= cognitive behavioural therapy
CET = cue exposure therapy
DD = drinking days
EMA = ecological momentary assessment
EMI = ecological momentary intervention
f/u = follow-up
IOP = intensified outpatient treatment
LETS ACT = life enhancement for substance use
m = month (s)
STD = sexually transmitted disease
SUD = substance use disorder
RCT = randomized controled trial
TAU = treatment as usual, here: usually in the re center withouth App
TLFB = timeline follow back
TMC = telefone monitoring and counse w

Table 2: Randomized controlled studies, authors, year, interventions, main app tool, primary secondary outcomes, results

communication with caregivers or referrals to self-help institutions. Alternatively, some teams proactively contacted patients who remained unresponsive for extended periods. Psychotherapeutic components, such as elements of CBT or MI, were consistently present and played a crucial role in the intervention (see above and tables 1,2).

Qualitative measures

These were addressed in 3 studies. Authors reported high user satisfaction [15], good acceptance and feasibility [16] as well as easy use and helpfulness [17].

Incentives

Several studies used incentives in form of free treatment, money or gift cards (which could not be used for buying alcohol), free smartphone use and/or keeping the smartphone at the end of the study [17,20,15,21,18,23,27-29]. In cases where money was awarded, the amount ranged from 70 € to 600 $. Except for two studies [16,23] incentives were introduced only in the studies conducted in the United States.

Discussion

This overview focuses on RCTs utilizig a hybrid model, where professionally managed mobile phone applications are integrated as add-ons to TAU for AUD and SUD treatment. Also the whole package is applied by one therapist or a team known to the individual under care. Comparing to the multitude of apps freely available [1], the number of studies incorporating apps as part of treatment is relatively small. The reasons for this include: (1) the complexity of addictive disorders; as with other chronic diseases, particularly psychiatric conditions, the chances of recovery without professional support are rare. As for the apps, (2) after a certain time users lose interest and lack a counterpart to discuss their progress and pitfalls. Morever, (3) commercial smartphone applications very often do not meet data safety requirements.

The heterogeneity of the studies is considerable. The variations among them are attributable to differences in the substances consumed, the inclusion or exclusion of comorbidities, sample size, study duration, variations in patients' socioeconomic status, and differences in the political contexts of the countries where the studies were carried out. Notably, 10 studies were conducted in the United States, 5 in Europe, and one in China. However, all applications provide core functionalities, including monitoring various parameters and offering relapse prevention tools.

Efficacy of apps

This overview demonstrates that smartphone applications, when used as add-ons to face-to-face treatment for AUD and SUD, may improve treatment outcome. Enhanced engagement, relapse prevention, and real-time support are possible benefits, particularly when tools incorporate elements of CBT and MI. However, sustained improvement often requires extended treatment periods of around one year or more and very likely personal support.

Key advantages of apps are

- Monitoring and personalization: Apps enable detailed tracking of consumption, cravings, and adherence, which helps to personalize treatment and maintain accountability.

- Motivational support: Features such as reminders, motivational messages and direct communication with healthcare providers enhance patient engagement.
- Relapse prevention: Emergency tools, geolocation features and personalized interventions provide real-time support in high-risk situations.
- Accessibility and cost: Apps offer a scalable and cost-effective complement to traditional therapy, potentially expanding access to underserved populations as smartphones and app-use are already an integral part of daily life.

Possible predictors of outcome

Two groups undertook a positive selection of motivated individuals, specifically excluding those who did not choose abstinence as a goal or when non-adherence was anticipated [23,24]. These choices do not reflect patients' and carers' reality. This is equally true for incentives.
Relevant predictors of outcome in the hybrid approaches seem to consist in personal support by therapists and the duration of treatment.

- Personal support: Our overview leads to the conclusion that studies reporting favorable or partially favorable outcomes demonstrated, in addition to app utilization, an increased frequency or regularity of personal contact and the incorporation of personalized care elements. These includes face-to-face or telephone interactions, tailored support when necessary, and the provision of opportunities for communication with caregivers or referrals to self-help institutions [17,21,22].
  Alternatively, some teams proactively contacted patients who remained unresponsive for extended periods [23,27,28]. Psychotherapeutic components, such as elements of CBT or MI, were consistently present and played a crucial role in the intervention.
  Up to the advent of ehealth treatment of addiction, counselling has been regarded as the cornerstone of treatment [30]. The literature also supports telephone counselling for AUD and SUD [31]. Different schools of psychotherapy – mostly psychodynamic and cognitive behavioral and their descendants – are applied for addiction treatment. Their effect sizes are mild to moderate [32] as is the case for counselling. As opposed to "regular" lengths therapies, brief interventions lead to small reduction in consumption, i.e. minus 1 glass / month [33].
  The COVID-pandemic brought about new ways of delivering psychotherapy, namely the transfer of face-to-face sessions to teletherapy. When compared to videotherapy teletherapy generates less distraction and is thus preferable. Overall, the advantages of face-to-face psychotherapy outweighs any other approach [34]. Thus this overview is in line with the relevant literature on the importance of personal contact with professional caregivers towards favorable outcome.
- Duration of treatment seems to influence outcome: Thompson et al. [17] and Aharonovich et al. [15] reported positive outcomes after only 1 to 2 months of treatment. This raises the question if initial high motivation was captured, and outcome may have been different if follow-ups had been performed. Consistent with this, studies with longer durations or follow-up periods observed increasing relapse rates at 3 to 6 months [19,18,24,25,28] or even drop-outs, as noted in a subgroup of one study [18]. However, the longest studies, specifically 12 to 18 months, reported the most favorable outcomes [4,23,27].
  Thus, shorter studies may have captured early improvements without accounting for the subsequent decline in the initial treatment effect. This hypothesis is supported by the observation that nearly all studies reported early improvement, likely driven by high initial motivation.

The previous notion is supported by the fact that reductions in consumption were observed in both, TAU and intervention groups by several authors [15,20,22,26-28]. This may be attributed to factors resulting from study participation, such as early motivation, heightened attention from professionals, or a combination of the above. Overall, a certain duration of treatment appears necessary to effect sustained changes in consumption patterns and to prevent relapse, which aligns with the chronic nature of the disease, as altering long-established behaviors typically requires time.

Limitations

This review has several limitations.
The number of studies included is relatively small.
Studies were heterogeneous. Patient demographics, app features, and treatment settings made direct comparison challenging. Heterogeneity was present with regard to the severity of addiction and the specific substances used, which were not always specified, nor was the stage in the overall course of the addiction and therapy at which the apps were implemented.
Several studies excluded patients with psychiatric comorbidities, limiting generalizability to real-world populations where such conditions are common.
There was a positive selection bias in two studies.
Some groups introduced substantial incentives to increase compliance with the study. While this did not seem to significantly improve outcome, the practice warrants critical discussion. Intrinsic motivation is, after all, a crucial factor in driving lasting behavior change.

The reviewed apps offered some similar functions but exhibit significant variability in content. This variability makes it difficult to determine to what extent the treatment outcomes were related to specific tools offered within the applications. It is especially important to investigate individualized response options and strategies, as well as their potential to extend the duration of app use, given that long-term engagement with apps is often problematic, with early decreases and discontinuation of use being common.
Additionally, the standard treatments provided alongside the app varied widely, ranging from outpatient consultations to more specialized therapeutic groups, further complicating the comparability of results.

Therefore, it remains an open question which combination of apps and conventional treatments may be both acceptable and effective in the long term, and how individuals with lower motivation and a tendency toward early dropout may be retained in treatment. Possible strategies discussed in the various articles include monitoring with real-time feedback, known as "ecological momentary assessment" (EMA), as well as facilitated contact with a caregiver and individualized interventions provided in high-risk situations, referred to as "ecological momentary intervention" (EMI).

Given the publication bias against null results, it is possible that more unsuccessful mobile-based interventions for alcohol and substance use exist than are reported in this review.

Further concerns regarding the representativeness and generalizability of the included RCTs arise from their geographic distribution. The cited studies are largely representative of North America, Europe, and possibly Oceania, given the similarities

in lifestyle across these regions (geographic bias). However, global generalizability is limited, as only one study from Asia was included, but none from Africa or South America. Additionally, vast rural areas with poor infrastructure may face unique challenges. While smartphone apps can bridge distances, the lack of addiction centers and healthcare personnel in remote areas may hinder their effective implementation including personal assistance. Lastly, homeless individuals – who are at an elevated risk for AUD and SUD – were largely underrepresented in the studies. They are also less likely to own a smartphone due to economic precarity, further limiting the generalizability of these findings.

The numbers suggest that the widespread allocation of smartphones may support hybrid treatments [1]. However, several challenges must be addressed before the hybrid model – combining apps with face-to-face therapy – can be widely implemented. These challenges include training healthcare providers, translating app content, adapting it to cultural specificities, addressing security concerns, and potentially accommodating issues related to illiteracy.

In summary: While the integration of eHealth tools into AUD and SUD treatment shows promise, their success depends on thoughtful design, consistent professional oversight, and adaptation to individual and contextual needs. Expanding their reach and addressing existing limitations can make them a more robust supplement to face-to-face care.

Practical Implications:

- *Integration with standard care:* Apps should not replace professional care but complement it as part of a comprehensive treatment plan. They do not replace the expertise, clinical judgment, and personalized care provided by healthcare professionals. Face-to-face interactions remain critical, particularly for patients with severe addiction and comorbidities.

- *Focus on long-term use:* App development should prioritize sustained engagement through features like personalized interventions, gamification, and regular caregiver involvement. As with any chronic disease, treatment outcomes are influenced by both the duration and intensity of the intervention.

- *Global adaptation:* Addressing cultural, linguistic, and infrastructural barriers is essential for broader implementation, particularly in low-resource settings.

Future research directions:

- *Long-term studies:* They should investigate the sustainability of app-related benefits, i.e. of the hybrid model beyond 12 months.

- *Tailored interventions:* They should identify which app features are most effective for a specific populations as well as addiction severities and determine the optimal balance of human and technological elements.

- *Global and Inclusive Trials:* Research should be conducted in diverse regions and include underrepresented groups, such as individuals experiencing homelessness.

Statements and Declarations

Statement of Ethics

An ethics statement is not applicable because this study is based exclusively on published literature.

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Conflict of Interest Statement / Financial Interests

Authors have no conflicts of interest to declare, no financial interests.

Author Contributions

Both authors conceptualized the manuscript, they searched and reviewed the existing literature. They validated and formally analyzed the data. Silke Bachmann wrote the article and Louise Penzenstadler reviewed and edited it.

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Table legends for tables 1 and 2

Legend 1 equals legend 2

AA = alcoholics anonymous
ACHESS = addiction comprehensive health enhancement support system
AOR = adjusted odds ration
AUD = alcohol use disorders
AUDIT = alcohol use disorders Identification test
age = mean age
BAI = Beck Anxiety Inventory
BDI = Beck's Depression Inventory
BMI = brief motivational interviewing
CBT= cognitive behavioural therapy
CD=consumption days
CET = cue exposure therapy
d=day(s)
DD = drinking days
DpDD = drinks per drinking day
EMA = ecological momentary assessment
EMI = ecological momentary intervention
f/u = follow-up
IOP = intensified outpatient treatment
LETS ACT = life enhancement for substance use
m = month(s)
OR = odds ratio
STD = sexually transmitted disease
SUD = substance use disorder
RCT = randomized controlled trial
TLFB = timeline follow back
TMC = telephone monitoring and counselling
TAU = treatment as usual, here: as usual in the respective center withouth App
w = week(s)