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Effectiveness of a digital alcohol intervention as an add-on to depression treatment for young adults: results of a pragmatic randomized controlled trial

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Abbreviations:
AUD: alcohol use disorder; AUDIT: Alcohol Use Disorders Identification Test; BtB: Beating the Booze; CBT: cognitive behavioral therapy; CES-D: Center for Epidemiological Studies-Depression; CI: confidence interval; CONSORT: Consolidated Standards of Reporting Trials; EMM: estimated marginal mean; GLM: generalized linear modeling; GLMM: generalized linear mixed model; ITT: intention-to-treat; MDD: major depressive disorder; MI: motivational interviewing; MICE: multivariate imputation by chained equations; OR: odds ratio; RCT: randomized controlled trial; RLMM: robust linear mixed model; S.D.: standard deviation; TAU: treatment as usual; TLFB: timeline follow-back

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Abstract

Background. Problematic drinking frequently co-occurs with depression among young adults, but often remains unaddressed in depression treatment. Evidence is insufficient on whether digital alcohol interventions can be effective in this young comorbid population. In a randomized controlled trial, we examined the effectiveness of Beating the Booze (BtB), an add-on digital alcohol intervention to complement depression treatment for young adults.
Methods. Participants were randomized to BtB + depression treatment as usual (BTB + TAU, $n = 81$) or TAU ($n = 82$). The primary outcome was treatment response, a combined measure for alcohol and depression after 6-month follow-up. Secondary outcomes were number of weekly drinks (Timeline Follow-back) and depressive symptoms (Center for Epidemiologic Studies Depression scale). Treatment response was analyzed using generalized linear modeling and secondary outcomes using robust linear mixed modeling.
Results. Low treatment response was found due to lower than expected depression remission rates. No statistically significant between-group effect was found for treatment response after 6-month follow-up (odds ratio 2.86, $p = 0.089$, 95% confidence interval [CI] 0.85–9.63). For our secondary outcomes, statistically significant larger reductions in weekly drinks were found in the intervention group after 3-month ($B = -4.00$, $p = 0.009$, 95% CI −6.97 to −1.02, $d = 0.27$) and 6-month follow-up ($B = -3.20$, $p = 0.032$, 95% CI −6.13 to −0.27, $d = 0.23$). We found no statistically significant between-group differences on depressive symptoms after 3-month ($B = -0.57$, $p = 0.732$, 95% CI −3.83 to 2.69) nor after 6-month follow-up ($B = -0.44$, $p = 0.793$, 95% CI −3.69 to 2.82).
Conclusions. The add-on digital alcohol intervention was effective in reducing alcohol use, but not in reducing depressive symptoms and treatment response among young adults with co-occurring depressive disorders and problematic alcohol use.
Trial registration:. Pre-registered on October 29, 2019 in the Overview of Medical Research in the Netherlands (OMON), formerly the Dutch Trial Register(https://onderzoekmetmensen.nl/en/trial/49219).

Introduction

Depressive disorders and alcohol use disorders (AUD) are among the most prevalent mental disorders (GBD 2016 Alcohol and Drug Use Collaborators, 2018; Liu et al., 2019). The onset of AUD, major depressive disorder (MDD) as well as comorbid AUD + MDD peaks during emerging adulthood (Briere, Rohde, Seeley, Klein, & Lewinsohn, 2014; Hamdi & Iacono, 2014; Pedrelli, Nyer, Yeung, Zulauf, & Wilens, 2015). Consequently, prevalence estimates of depression and AUD among young adults from the general population are relatively high, with 12-month prevalence ranging from 7.3% to 17.2% for depressive disorders and from 8.8% to 12.3% for AUD (Goodwin et al., 2022; Lu, Kim, Yoon, Yun, & Solomon, 2022; Mewton, Teesson, Slade, & Grove, 2011; Mojtabai, Olfson, & Han, 2016; Pedrelli, Shapero, Archibald, & Dale, 2016). Problematic alcohol use, including both AUD and non-clinical forms of hazardous drinking, frequently co-occurs with depressive disorders among young adults. Twelve-month prevalence rates have been estimated at 3.4% for co-occurring depression and AUD and 11.4% for co-occurring affective disorders and AUD among young adults from the general population (Lu et al., 2022; Mewton et al., 2011). A study by Briere et al. (2014) found lifetime prevalence rates up to

20.5% for comorbid MDD and AUD among young adults (Briere et al., 2014). Compared to either condition alone, co-occurring depression and problematic alcohol use has been associated with even more adverse health outcomes, including an increased risk of alcohol dependence and suicide attempts and lower global functioning and life satisfaction (Briere et al., 2014). Thus, intervening early among young people with these co-occurring conditions is of utmost importance.

In psychological combined treatment for comorbid depression and problematic alcohol use both alcohol use and depression can be addressed in sequential, parallel, or integrated treatment formats (Hobden et al., 2018). Strong empirical evidence is still lacking on which of these formats is superior to single-disorder treatment (Hesse, 2009; Hobden et al., 2018). However, increasing support has been found for combined psychological treatments that address both alcohol use and depression and are based on motivational interviewing (MI) and cognitive behavioral therapy (CBT). These combined CBT/MI-based treatments have been found to be effective in reducing alcohol use and depressive symptoms among the adult comorbid population (Baker, Thornton, Hiles, Hides, & Lubman, 2012; Riper et al., 2014). Interventions targeting both alcohol use and depression may therefore also be suitable for young adults with these co-occurring conditions. However, treatment use for AUD among younger populations with either AUD and co-occurring depression and AUD is generally low (Lu et al., 2022; Lu, Xu, Goodwin, Muñoz-Laboy, & Sohler, 2023). To clarify, between 2011 and 2019 only 9.5–11.7% of the U.S. young adults with co-occurring depression and AUD were treated for their alcohol problems and less than 9.0% received treatment for both co-occurring conditions. Contrarily, treatment use for depression increased between 2011 and 2019 among young adults with these co-occurring conditions (Lu et al., 2022). This illustrates the importance of improving treatment use for alcohol problems among this young comorbid population, for example by tailoring alcohol-related treatments to young adults and providing digital treatment options as an add-on to depression treatment. Nevertheless, treatments tailored to young adults with co-occurring depression and substance use still seem scarce, although the research field is growing (Deady, Teesson, & Kay-Lambkin, 2014; Schouten, Derksen, Dekker, Goudriaan, & Blankers, 2023a).

Young adults appear to experience barriers for mental health help-seeking, these include stigma, difficulties recognizing mental health symptoms, not being ready to stop drinking, and preference for self-reliance as opposed to seeking external help (Ebert et al., 2019; Pretorius, Chambers, & Coyle, 2019; Wu, Pilowsky, Schlenger, & Hasin, 2007). Moreover, young people may not relate to current alcohol-related treatment programs, as these seem often aimed at older adults (Schouten et al., 2023b; Wu et al., 2007). This underscores the importance of improving accessibility and tailoring treatment for problematic alcohol use to young adults with these co-occurring problems. It could be argued that by offering a low-threshold digital alcohol self-help intervention as an add-on to depression treatment, treatment use for alcohol problems may increase among young adults with depression. Digital interventions seem promising considering the potential benefits, including: accessibility, 24/7 availability, possibility of tailoring, perceived anonymity, and alignment to preferences of young adults to handle problems on their own (Ebert et al., 2019; Olff, 2015; Van't Hof, Cuijpers, & Stein, 2009). Meta-analytic evidence suggests that digital interventions for adults with co-occurring depression and problematic alcohol use may be effective, yet the research field is still small and the quality of evidence not high (Riper et al., 2014; Schouten et al., 2022). Furthermore, a very recent systematic review by O'Donnell et al. (2022) found limited evidence of effectiveness of such digital interventions for people with comorbid heavy drinking and depression among community-dwelling populations. These reviews emphasize that research on digital interventions for especially young adults with these co-occurring conditions is still in its infancy and underscores the need for more high-quality randomized controlled trials (RCTs) (O'Donnell et al., 2022; Riper et al., 2014; Schouten et al., 2022).

Considering the previously discussed literature, we developed 'Beating the Booze' (BtB), an add-on guided tailored digital alcohol intervention to complement depression treatment for young adults with co-occurring depressive disorders and problematic alcohol use. BtB was developed to be followed simultaneously, but not integrated with, outpatient treatment as usual (TAU) for depression. Guidance was aimed at increasing program adherence and not care-related. In this study, we aimed to examine the effectiveness of BtB + TAU compared to TAU alone on alcohol and depression outcomes after 3- and 6-month follow-up, among young adults with co-occurring depressive disorders and problematic alcohol use. We hypothesized significant improvements in alcohol use and depression outcomes at 6-month follow-up in the BtB + TAU group.

Methods

Design

This study was a two-arm single-blind multicenter RCT with parallel-group design using 1:1 randomization ratio, conducted in the Netherlands. Online self-report assessments took place at baseline and after 3, 6 (primary endpoint RCT), and 12 months (not included in this paper) post-randomization.

The study protocol was approved by the Medical Research Ethics Committees United in the Netherlands (NL66899.100.18) and conducted in accordance with the Helsinki declaration (World Medical Association, 2013). Written digital informed consent was obtained from all study participants prior to study participation. The study was pre-registered on October 29, 2019 in the Overview of Medical Research in the Netherlands (OMON), formerly the Dutch Trial Register (https://onderzoekmetmensen.nl/en/trial/49219). Details of the study protocol and intervention development have been described elsewhere (Schouten et al., 2021, 2023a). This paper was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guideline (Moher et al., 2012).

Participants

Inclusion criteria were: (1) 18–35 years old, (2) diagnosis of a depressive disorder and either enrolling or currently in treatment, (3) a total score of ≥8 (men) and ≥5 (women) on the Alcohol Use Disorders Identification Test (AUDIT), (4) at least moderately proficient in Dutch, (5) provided contact details, (6) healthcare insurance coverage, (7) access to a computer or mobile device, and (8) provided written informed consent. Depression diagnoses were obtained through self-report and when possible through medical records. Exclusion criteria were: (1) acute psychosis, (2) primary diagnosis of severe AUD, (3) dementia, (4) (waitlisted for) in-patient mental health care, and (5) pregnancy.

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Participant recruitment

The study was partly conducted during the COVID-19 pandemic. Participants were recruited from November 18, 2019 until March 27, 2021, through social media advertisements and at three participating sites of Arkin Mental Health Care in the Netherlands. The first site focused exclusively on youth (0–23 years), the second on adults with mild-to-moderate mental health problems, and the third site was specialized in mood- and anxiety disorder treatment. Both recruitment strategies may serve as potential implementation channels when the intervention is deemed (cost-)effective. Data collection for 6-month follow-up was completed on October 30, 2021. Participants received a €20 gift voucher for every completed follow-up assessment.

Details of the participant recruitment are published elsewhere (Schouten et al., 2021). In short, applicants (aged 18–35) enrolling for depression treatment at the participating sites of Arkin Mental Health Care were pre-screened based on the AUDIT-C. Applicants interested in study participation and with elevated AUDIT-C total scores (i.e. ≥2 and ≥3 for women and men, respectively), were screened for eligibility based on inclusion and exclusion criteria through an online screening questionnaire (including the AUDIT questionnaire). Eligible applicants received detailed study information and were invited to sign the informed consent form digitally. Study participants completed the online baseline assessment no sooner than 4 weeks before the start of their treatment and were randomized after baseline assessment completion.

Social media recruitment was conducted through Facebook and Facebook audience network advertisements (e.g. Instagram, Messenger). Young adults who were either soon to start or currently in depression treatment were invited to complete an online screening questionnaire in which eligibility for study participation was assessed. Eligible potential participants received study information and were invited to sign the informed consent form for study participation. The informed consent was later validated in a personal contact (e.g. by phone) between the participant and a research team member. Subsequently, participants completed the baseline assessment after which they were randomized.

Interventions

Digital alcohol intervention: 'Beating the Booze'

BtB is a web-app designed as a fixed-order CBT/MI-based modular self-help with five modules and one aftercare module. It was developed to be followed simultaneously, but not integrated with TAU. The program was mainly aimed at reducing alcohol use toward a personalized goal, either abstinence or (gradually) controlled drinking toward a self-chosen maximum amount of weekly drinks. Key program elements were the modules and daily recording of alcohol use (and optional mood and activities). Each module contained psychoeducation and assignments on a specific theme aimed at reducing alcohol use and included: a short animated video, reading assignments, assignments, patient stories, and a short self-reflection assessment that summarized the module's key points. Depression and underlying interactions with alcohol use were also addressed. Each module was self-paced and could be completed in multiple sessions, and took approximately 30–45 min to complete. See online Supplement S1 for a detailed overview of the content and features of BtB. Optional features included (but not limited to) forum boards and visual progress reports of the participants' alcohol use patterns. Automatic e-mail-based reminders were sent after certain periods of inactivity or to inform participants of newly accessible modules. BtB included a minimal level of asynchronously delivered adherence-focused guidance from a coach (i.e. research team member). Guidance was delivered by e-mail, text message, and phone calls by a Ph.D. student or supervised research assistants, and focused on increasing program adherence by motivating and reminding participants to log-in after certain time of inactivity, and thus tailored to the participant's activity level.

Treatment as usual

Participants received various forms of regular treatment for depressive disorders, for example CBT, acceptance, and commitment therapy or other evidence-based psychotherapies supplemented with medication, if necessary. TAU was delivered in line with the Dutch multidisciplinary guidelines for depression treatment (Spijker et al., 2013). TAU was often given at secondary specialized mental health care services (e.g. for severe mental health problems) or primary mental health care (i.e. for mild-to-moderate mental health problems). TAU was delivered face-to-face, blended (combination of face-to-face and digital), or exclusively digitally (e.g. through video calls).

Outcomes

Primary outcome

The primary outcome parameter was treatment response at 6-month follow-up. Treatment response (yes/no) was achieved if all three criteria were met: (I) drinking less than 21 (men) or 14 (women) standard glasses of alcohol in the last week, (II) 0 days with 4 or more (women), or 5 or more (men) standard drinks in the last 7 days, and (III) a total score of <16 on the Center for Epidemiological Studies-Depression (CES-D) questionnaire or a reduction of 40% relative to the patients' CES-D total score at baseline. Criteria I and II are based on Dutch excessive alcohol use norms and international binge drinking criteria, respectively (Corbin et al., 2014; Courtney & Polich, 2009; State of Health and Care, 2022). Criterion III was based on the recommended CES-D cut-off (i.e. <16, range 0–60) for detection of depression cases (Radloff, 1977) and the 40% self-report CES-D reduction cut-off was chosen together with clinical experts, as both criteria can be considered treatment success.

Alcohol use for the treatment response criteria I and II was measured with the widely used self-report 7-day timeline follow-back (TLFB) questionnaire. The TLFB uses a retrospective calendar method in which the daily number of standard drinks in the past 7 days is reported (Sobell & Sobell, 1992). For criterion III, depressive symptoms in the past week were measured with the brief 20-item CES-D self-report questionnaire (Radloff, 1977). The CES-D has shown acceptable screening accuracy in both general population and primary care settings (Vilagut, Forero, Barbaglia, & Alonso, 2016).

Secondary outcomes

Secondary outcomes were depressive symptoms (CES-D), number of weekly drinks (TLFB), and hazardous, harmful, and dependent drinking patterns (AUDIT) (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001; Radloff, 1977; Sobell & Sobell, 1992).

Other measures

Various characteristics were assessed at baseline. Sociodemographic characteristics were: gender, age, highest level of completed

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education, employment status, marital status, and country of birth of the participants and their parents. Clinical characteristics included: depression diagnosis, current phase of depression treatment (based on self-reported completed and total number of sessions), TAU location (e.g. primary or secondary mental health care), and medication use (measured with the self-report Treatment Inventory Cost in Psychiatric Patients) (Kanters et al., 2019). We report the medication types used by more than 10% of the study sample. Treatment satisfaction was measured with the Client Satisfaction Questionnaire-8 (ZUF-8) at 3-month follow-up (Schmidt & Wittmann, 2002). On May 27, 2020, a self-constructed COVID-19 questionnaire similar to Olthof, Goudriaan, van Laar, and Blankers (2023) was included in all assessments to measure the impact of COVID-19 and related restriction measures of the past 3 months on current depressive symptoms and alcohol use. Olthof et al. used this COVID-19 questionnaire to measure the impact of the pandemic on cannabis use; therefore, we adjusted it to depression and problematic alcohol use.

Sample size

The sample size calculation was based on the primary outcome and calculated using the R package 'pwr' with alpha (α) set on 0.05 (two-sided) and power ($1-\beta$) of 0.80 (Champely et al., 2018) with a 1:1 allocation ratio. A 35% extra inclusion was taken into account in order to deal with drop-out and the multicenter clustering effect of the RCT design. We expected 25% treatment response effect difference between groups. This resulted in a required sample size of 156 participants, evenly distributed over the two trial arms.

Randomization

Participants were randomized in a 1:1 ratio to either the intervention or control group. We used the stratified variable block randomization feature in Castor EDC, with block sizes of 2 and 4 and strata for every participating site and for the social media-recruited participants (Castor EDC, 2019). The randomization sequence was concealed for all research team members. Participants were not blinded to treatment conditions.

Main statistical analyses

Missing data were imputed with multiple imputation techniques, using the random forest imputation algorithm in the Multivariate Imputation by Chained Equations (MICE) package in R (R Core Team, 2020; van Buuren & Groothuis-Oudshoorn, 2011). The imputation model included all variables from the analyses models, as well as auxiliary variables (e.g. sociodemographic variables). We created 20 imputed sets. Convergence of the multiple imputations was evaluated through convergence plots, and was achieved after five iterations.

All statistical analyses were performed in R version 3.6.3 (R Core Team, 2020). All statistical tests were two-sided with $\alpha = 0.05$. The main analyses were based on intention-to-treat (ITT) principles. Two minor deviations from our analysis plan occurred. First, we used robust estimation of linear mixed-effects modeling (hereafter robust linear mixed model [RLMM]) instead of the previously reported generalized linear mixed models (GLMM) for estimating the secondary outcomes intervention effects (Schouten et al., 2021). RLMM, using the Robustlmm package, is an innovative and robust version of GLMM which can be used irrespective of whether the data are normally distributed or skewed, the latter is often the issue with alcohol use data (Koller, 2016). Second, due to convergence issues (i.e. extremely wide confidence intervals [CIs]) in our GLMM, we analyzed the treatment response outcome with generalized linear modeling (GLM) with a binomial link function. GLM is a less complex model in which the data are separately analyzed for every timepoint.

We report the crude models, adjusted only for the baseline value of the outcome and the full adjusted models including age, gender, recruitment strategy, baseline value of the outcome, and the impact of COVID-19 measures on alcohol use and depressive symptoms. Considering the comorbid population, we included the CES-D score as covariate for both the adjusted AUDIT and TLFB models, and the TLFB was included as covariate in the adjusted CES-D model. We consider the full adjusted models as the main findings. Based on the full adjusted main models, we calculated for each outcome the estimated marginal mean (EMM) and standard deviations (S.D.) separately for every group at each timepoint. For treatment response we used fitted EMMs based on the GLM-based model, and for all the secondary outcomes predicted RLMM-based EMMs were used. Cohen's D (d) effect sizes were calculated for all statistically significant effects based on the EMMs (Cohen, 1988).

Additional statistical analyses

We performed our main analyses on a returning program users sample to examine the impact of analyzing under ITT principles and to explore treatment effects among returning BtB users. Consequently, we excluded the participants without a BtB account and those who did not return at least once after full account registration (i.e. account creation and e-mail confirmation, resulting in two log-ins). Thus, returning users were defined as users with a minimum of ≥3 log-ins into BtB. Subsequently, 17 participants were excluded from the BtB + TAU group. Additionally, we conducted sensitivity analyses on a non-imputed completers-only dataset to examine the impact of our missing data strategy on our main findings.

Treatment satisfaction was examined using linear regression models, including both a crude and adjusted model for age, gender, recruitment strategy, baseline TLFB, baseline CES-D scores, and impact of COVID-19 measures.

Results

Sample characteristics

In total, 163 participants were included in the study and analyses, response rates on the 3- and 6-month follow-up assessments were 86.5% and 85.3%, respectively (Fig. 1). The majority of the sample was female (77.9%), while the mean (M) age was 25.08 years (S.D. 4.52). At baseline, participants drank on average 16.19 weekly alcoholic drinks (S.D. 13.70, median 13.00, interquartile range 15.25) and AUDIT scores (M 15.21, S.D. 6.96) indicate at least harmful drinking patterns in the past year. The CES-D scores (M 30.36, S.D. 10.67) were indicative of severe depressive symptoms (Table 1). Social media-recruited participants had a higher AUDIT score (M 17.82, S.D. 6.73) than traditional-recruited participants (M 11.28, S.D. 5.29, $p \leq 0.001$). Depressive symptoms were similar for both recruitment groups (social media: CES-D M 30.84, S.D. 10.67; traditional: M 29.63, S.D. 10.70, $p = 0.480$).

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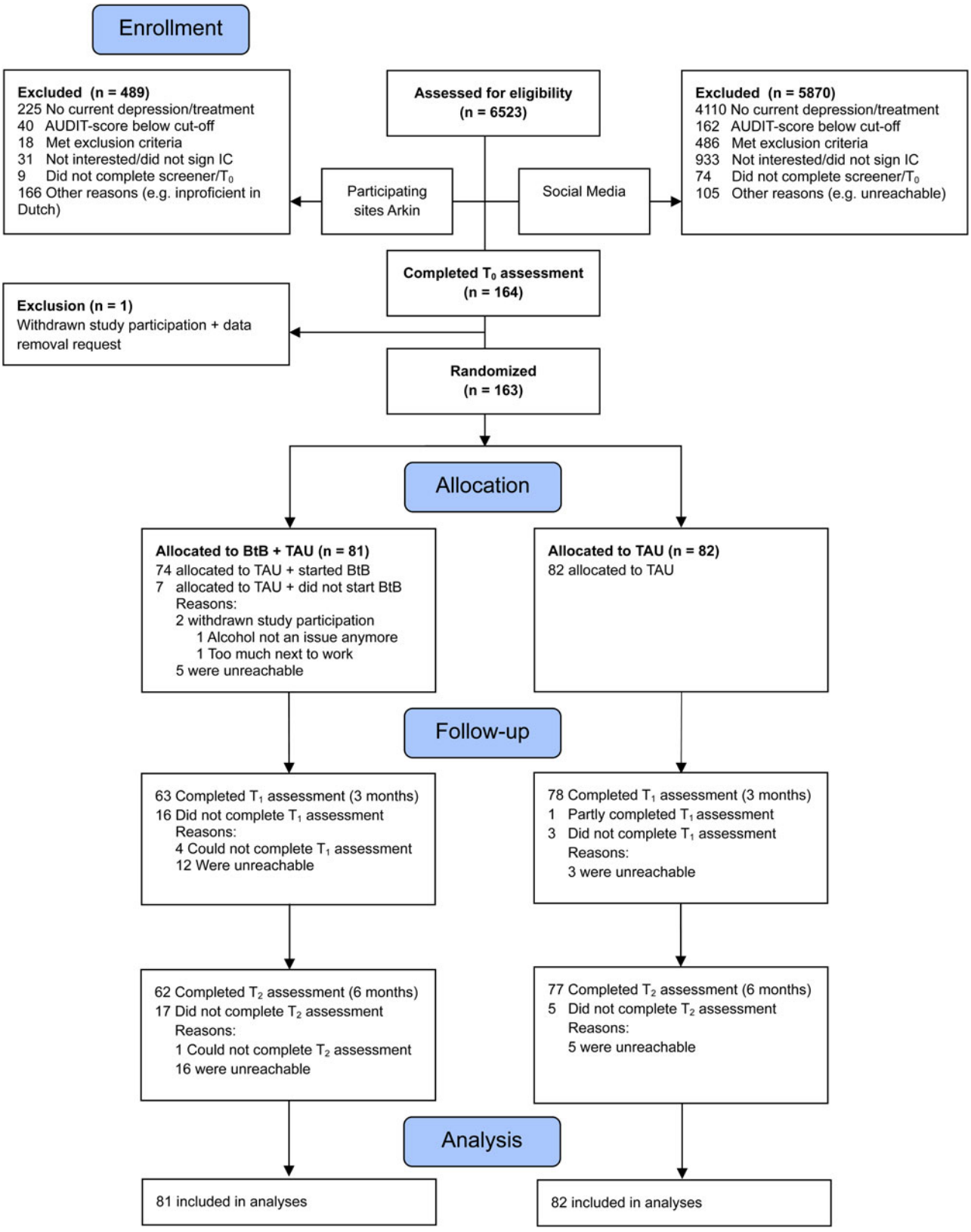

Figure 1. Participant flowchart.

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Table 1. Descriptive characteristics of study sample

	Intervention group ($n = 81$)		Control group ($n = 82$)	
	N	(%)	*N*	(%)
Sociodemographics				
Female	58	(71.6)	69	(84.2)
Age, mean [s.d.]	24.91	[4.40]	25.24	[4.65]
Highest completed education level[a]				
Low	10	(12.4)	9	(11.0)
Intermediate	41	(50.6)	38	(46.3)
High	30	(37.0)	35	(42.7)
Employment status				
Student	32	(39.5)	33	(40.2)
Paid job	37	(45.7)	35	(42.7)
Looking for a job	9	(11.1)	5	(6.1)
Other (e.g. house wife/men, sick leave)	3	(3.7)	9	(11.0)
Marital status				
Married/living with partner	22	(27.2)	17	(20.7)
With partner, not living together	19	(23.5)	21	(25.6)
Single	40	(49.4)	44	(53.7)
Participants' country of birth				
The Netherlands	75	(92.6)	77	(93.9)
Other	6	(7.4)	5	(6.1)
Background				
Dutch	70	(86.4)	68	(82.9)
Western migration	6	(7.4)	4	(4.9)
Non-western migration	5	(6.2)	10	(12.2)
Recruitment strategy				
Recruited through social media	50	(61.7)	49	(59.8)
Clinical characteristics				
Depression diagnosis[b]				
Major depressive disorder	43	(56.6)	38	(46.9)
Persistent depressive disorder	13	(17.1)	10	(12.4)
Other depressive disorders[c]	17	(21.0)	26	(31.7)
Non-clinical diagnosis				
Severe depressive symptoms[d]	3	(3.7)	7	(8.5)
Depression treatment location				
Primary mental health care	22	(27.2)	29	(35.4)
Secondary mental health care	35	(43.2)	36	(43.9)
Primary/secondary mental health care	6	(7.4)	11	(13.4)
GP/GP mental health worker	3	(3.7)	1	(1.2)
Complementary health care	2	(2.5)	0	(0)
Other (e.g. not disclosed, none)	13	(16)	5	(6.1)
Phase of depression treatment at baseline				
Waitlisted/not started	16	(19.8)	9	(11.1)

(*Continued*)

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Table 1. (*Continued.*)

	Intervention group ($n = 81$)		Control group ($n = 82$)	
	N	(%)	*N*	(%)
First half of treatment	50	(61.7)	52	(64.2)
Second half of treatment	15	(18.5)	20	(24.7)
Medication use				
Antidepressants	19	(23.5)	17	(20.7)
Benzodiazepines	12	(14.8)	10	(12.2)
Secondary outcomes				
Weekly alcoholic drinks mean [s.d.]	16.65	[14.80]	15.75	[12.61]
AUDIT total score mean [s.d.]	15.81	[6.51]	14.61	[7.38]
CES-D total score mean [s.d.]	31.70	[10.09]	29.02	[11.11]
COVID-19 measures[e]				
Influence COVID-19 measures on alcohol use				
Increase in alcohol use	39	(48.2)	35	(42.7)
No influence	14	(17.3)	13	(15.9)
Reduction in alcohol use	23	(28.4)	28	(34.2)
Influence COVID-19 measures on depressive symptoms				
Increase in depressive symptoms	57	(70.4)	54	(65.9)
No influence	12	(14.8)	12	(14.6)
Decrease in depressive symptoms	7	(8.6)	10	(12.2)

[a]Lower indicates primary education or lower general secondary education; middle, intermediate vocational education of higher high school level; and high, higher vocational education or university.
[b]Missing for six participants, these participants have a mean CES-D score of 21.83 (s.d. 14.87), indicating moderate depressive symptoms (Park & Yu, 2021).
[c]Other depressive disorders include: premenstrual dysphoric disorder, depressive disorder due to another medical condition, other specified depressive disorder, unspecified depressive disorder.
[d]Mean CES-D scores (intervention group 31.33 [s.d. 8.51]; control group 34.00 [s.d. 9.24]) indicate severe depressive symptoms (Park & Yu, 2021).
[e]Missing for 11 participants since COVID-19 questionnaire was added later to the baseline assessment.

Digital intervention uptake

A total of 74 participants (91.4%) created an account for BtB, of which 32 (43.2%) did not go further the first module. Thirty-five participants (47.3%) reached the third module, whereas 21 (28.4%) users reached the last module and 14 (18.9%) participants completed all six modules. The number of log-ins and activity duration (i.e. start date minus last logged activity date) varied widely. Among all users, the mean number of log-ins was 19.45 (s.d. 25.65, range 1–134). Interestingly, some participants who remained in the first program module did frequently use the program (range 1–67, mean 6.25, s.d. 12.12). Participants were on average 88.46 days active in the program (s.d. 103.98, range 0–452 days). Returning users (i.e. users with ≥3 log-ins) had on average 22.22 log-ins (s.d. 26.55).

Treatment effects

The EMMs for all outcomes are presented in Table 2 and Fig. 2; the main findings are shown in Table 3; and the additional analyses can be found in the online Supplement (S2 and S3).

Treatment response

With regard to the treatment response criteria, 54.1% of the intervention group met both alcohol use criteria (I and II) compared to 40.6% of the control group after 6-month follow-up. However, only 27.8% of the intervention group met the depression criterion (III) in comparison with 30.9% of the control condition. Consequently, only a small proportion of participants achieved treatment response (Table 2). Concerning our primary outcome, the proportion treatment response in the intervention group was 0.0 at baseline and 0.11 (s.d. 2.76) at 6-month follow-up, and remained stable in the control group (baseline: 0.03, s.d. 1.50; 6-month follow-up: 0.03, s.d. 1.61). In the main analyses, no statistically significant between-group differences were found on treatment response (Table 3). The adjusted models showed no statistically significant between-group differences in treatment response after 3-month follow-up (odds ratio [OR] 1.00, $p = 0.995$, 95% CI 0.25–3.95). After 6-month follow-up, subjects in the BtB + TAU group had a 2.86 higher odds of treatment success compared to the TAU group, but this was not statistically significant (OR 2.86, $p = 0.089$, 95% CI 0.85–9.63).

Alcohol use

Both groups reduced their alcohol use over time (Table 2). Participants in the intervention group drank on average 16.52 (s.d. 10.75) weekly drinks at baseline and 9.24 (s.d. 9.29) weekly drinks after 6-month follow-up. The control group drank on average 15.84 (s.d. 9.43) weekly drinks at baseline and 11.44 (s.d. 9.02)

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Table 2. Model EMMs for intervention and control groups over time

Follow-up	Treatment response Proportion (s.d.)		7-day TLFB Mean (s.d.)		AUDIT Mean (s.d.)		CES-D Mean (s.d.)	
	Intervention	Control	Intervention	Control	Intervention	Control	Intervention	Control
Baseline	0.00 (0.00)	0.03 (1.50)	16.52 (10.75)	15.84 (9.43)	15.82 (5.52)	14.61 (6.27)	31.70 (7.56)	29.03 (8.88)
3-month	0.02 (1.17)	0.01 (1.04)	9.90 (9.94)	12.43 (8.61)	11.94 (5.29)	12.77 (6.19)	27.05 (7.64)	25.39 (8.34)
6-month	0.11 (2.76)	0.03 (1.61)	9.24 (10.05)	11.44 (9.02)	11.29 (5.45)	12.00 (6.14)	25.90 (7.38)	23.47 (8.63)

Treatment response on both I and II alcohol criteria at 3- and 6-month follow-up: intervention group 46.9% and 54.1%, control group: 38.7% and 40.6%, respectively.
Treatment response on III depression criteria at 3- and 6-month follow-up: intervention group 24.2% and 27.8%, control group: 24.8% and 30.9%, respectively.

weekly alcoholic drinks after 6-month follow-up. Both crude and adjusted mixed models showed statistically significant between-group differences on weekly alcohol use, in favor of the intervention group (Table 3). The adjusted model yielded a statistically significant larger reduction in weekly number of alcoholic drinks for the BtB + TAU group after 3-month follow-up, in comparison with TAU ($B = -4.00$, $p = 0.009$, 95% CI −6.97 to −1.02, $d = 0.27$), as well as after our primary end-point of 6-month follow-up ($B = -3.20$, $p = 0.032$, 95% CI −6.13 to −0.27, $d = 0.23$).

Similar significant effects were found for the AUDIT outcome (Table 2). The intervention group had a baseline mean AUDIT score of 15.82 (s.d. 5.52) and 11.29 (s.d. 5.45) at 6-month follow-up. The control group had an average baseline AUDIT score of 14.61 (s.d. 6.27) and 12.00 (s.d. 6.14) at 6-month follow-up. Consequently, the adjusted mixed model yielded a significant larger reduction in AUDIT scores in the BtB + TAU group compared to the TAU group at 3-month follow-up ($B = -2.29$, $p = 0.002$, 95% CI −3.71 to −0.86, $d = 0.15$) as well as after 6-month follow-up ($B = -2.06$, $p = 0.007$, 95% CI −3.54 to −0.57, $d = 0.12$).

Depressive symptoms

We found similar reductions in depressive symptoms over time in both groups (Table 2). The BtB + TAU group had a baseline mean CES-D score of 31.70 (s.d. 7.56) and 25.90 (s.d. 7.38) after 6-month follow-up. The TAU group had on average a baseline CES-D score of 29.03 (s.d. 8.88) and 23.47 (s.d. 8.63) after 6-month follow-up. Consequently, no statistically significant between-group differences in depressive symptoms were found after 3-month follow-up ($B =$

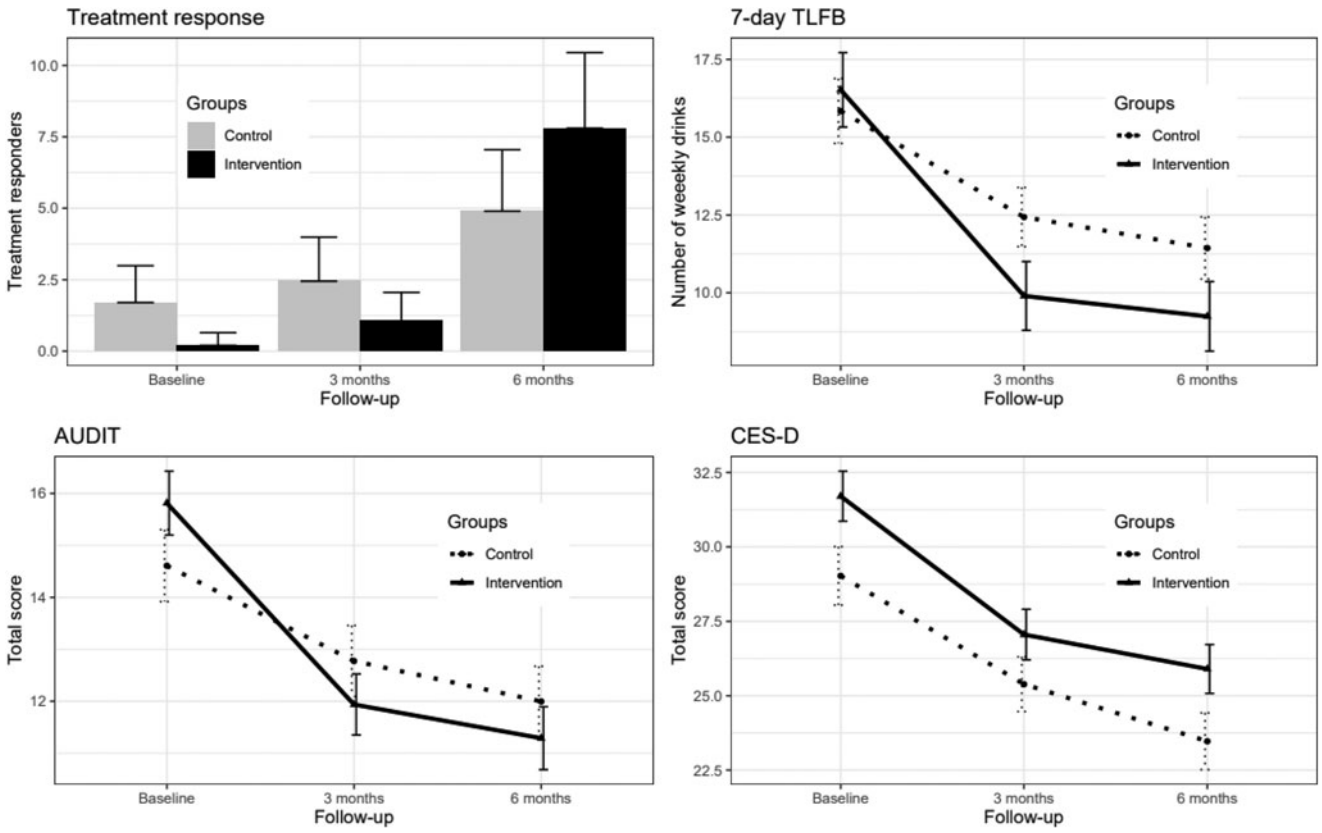

Figure 2. Treatment effects for primary and secondary outcomes.
Note: Plots for the CES-D, AUDIT, and TLFB present the EMMs and s.e. Bar plot for treatment response presents the number of treatment responders and s.d. which was calculated under the Poisson distribution ($\sigma = \sqrt{\mu}$) (Siegel & Wagner, 2022).

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Table 3. Treatment effect models for primary and secondary outcomes

Outcome	Follow-up	Model[a]	*B* or OR[b]	*p*	95% CI	
					Lower	Upper
Primary						
Treatment response	3-month	Crude	1.25	0.703	0.40	3.90
		Adjusted	1.00	0.995	0.25	3.95
	6-month	Crude	1.78	0.235	0.69	4.63
		Adjusted	2.86	0.089	0.85	9.63
Secondary						
7-day TLFB	3-month	Crude	−3.29	0.029	−6.23	−0.35
		Adjusted	−4.00	0.009	−6.97	−1.02
	6-month	Crude	−3.06	0.040	−5.98	−0.14
		Adjusted	−3.20	0.032	−6.13	−0.27
AUDIT	3-month	Crude	−2.14	0.003	−3.56	−0.73
		Adjusted	−2.29	0.002	−3.71	−0.86
	6-month	Crude	−1.95	0.012	−3.46	−0.44
		Adjusted	−2.06	0.007	−3.54	−0.57
CES-D	3-month	Crude	−1.00	0.555	−4.33	2.33
		Adjusted	−0.57	0.732	−3.83	2.69
	6-month	Crude	−0.28	0.870	−3.67	3.10
		Adjusted	−0.44	0.793	−3.69	2.82

AUDIT: alcohol use and alcohol-related problems (total score, 0–40); CES-D: depressive symptoms (total score, 0–60).
[a]Crude models are adjusted for the baseline outcome variable, adjusted treatment response model: adjusted for treatment response at baseline, impact of COVID-19 measures on alcohol use and depressive symptoms, recruitment strategy, age, gender; adjusted 7-day TLFB model: adjusted for both baseline 7-day TLFB and CES-D scores, impact of COVID-19 measures on alcohol use and depressive symptoms, recruitment strategy, age, gender; adjusted AUDIT model: adjusted for both baseline AUDIT and CES-D scores, impact of COVID-19 measures on alcohol use and depressive symptoms, recruitment strategy, age, gender; adjusted CES-D model: adjusted for baseline CES-D scores and 7-day TLFB, impact of COVID-19 measures on alcohol use and depressive symptoms, recruitment strategy, age, gender.
[b]Treatment response effects are presented as OR and secondary outcomes effects as regression coefficients (*B*).

−0.57, $p = 0.732$, 95% CI −3.83 to 2.69), nor after 6-month follow-up ($B = -0.44$, $p = 0.793$, 95% CI −3.69 to 2.82).

Additional analyses

Additional analyses on the returning users sample yielded similar significant results as the main analyses for both alcohol outcomes and non-significant findings for depressive symptoms and most treatment response models (online Supplement S2: Table 4). Except for the adjusted between-group difference for treatment response at 6-month follow-up, which was found statistically significant (returning users: OR 3.56, $p = 0.042$, 95% CI 1.05–12.15). Analysis of the non-imputed completers-only dataset resulted in more pronounced treatment effects compared to the analyses on the multiple imputed dataset (online Supplement S3: Table 5). Sensitivity analyses findings for treatment response and alcohol use corroborate our main findings. Except for the adjusted model for treatment response at 6-month follow-up, which was statistically significant in the non-imputed dataset, but not in the imputed dataset. An inconsistent trend in depressive symptoms was found in the crude model at 3-month follow-up ($p = 0.079$), but not in the adjusted model.

Treatment satisfaction and adverse events

Both groups were moderately to largely satisfied with the received treatment (BtB + TAU: *M* 22.80, S.D. 3.13, TAU: *M* 22.04, S.D. 4.56). No between-group differences were found (crude: $B = 0.757$, $p = 0.226$, adjusted: $B = 0.642$, $p = 0.306$). No adverse events were reported during the trial.

Discussion

Main findings

This study aimed to evaluate the effectiveness BtB + TAU compared to TAU for young adults with co-occurring depression and problematic alcohol use. Our main findings indicate that BtB + TAU yielded no strong effect on treatment response, our primary outcome. Overall: the proportion of participants who yielded treatment response was low under both conditions. Despite this low overall treatment response, the between-group difference on treatment response at 6-month follow-up was in favor of the BtB + TAU group, but not statistically significant (i.e. OR = 2.86, $p = 0.089$). With regard to our secondary outcomes, we found small but significant 3-month and 6-month follow-up effects on both alcohol use outcomes in favor of BtB

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+ TAU. Contrary to our hypothesis, no treatment effect of BtB + TAU was found on depressive symptoms. Additional analysis on the returning users sample did suggest a statistically significant treatment response effect at 6-month follow-up. This may indicate that participants who were exposed to the intervention might experience larger increases in treatment response, but this should be interpreted with caution due to the wide CIs.

Comparison with the literature

In our recent review we found only two studies that were conducted among young adults, indicating that research on digital interventions for young adults with co-occurring depression and problem drinking is still in its infancy (Schouten et al., 2022). The few RCTs that have been conducted report mixed findings of its effectiveness (Deady, Mills, Teesson, & Kay-Lambkin, 2016; Frohlich et al., 2021; Geisner, Kirk, Mittmann, Kilmer, & Larimer, 2015a). Our study is the first to demonstrate consistent short- and long-term effects on weekly alcoholic drinks (TLFB) and hazardous drinking patterns (AUDIT). To illustrate, one study found no effect of a brief web-based personalized feedback intervention for students with comorbid risky alcohol use and depressed mood (Geisner, Varvil-Weld, Mittmann, Mallett, & Turrisi, 2015b). Post-treatment effects on alcohol and depression outcomes were found for a 4-h modular web-based self-help among young adults, but these were not maintained after 3 and 6 months (Deady et al., 2016). More recently, an integrated minimally guided digital intervention was also found effective in reducing hazardous drinking (AUDIT-C) and depressive symptoms among young adults, but not on weekly alcohol consumption after 2-month follow-up (Frohlich et al., 2021). Six-month follow-up effects were only found for hazardous drinking, but should be interpreted with caution (Frohlich et al., 2021). Taken together, these studies' findings demonstrate that digital interventions for young comorbid populations seem promising. The mixed findings might be attributed to differences in methodological study design (active *v.* inactive control group), intervention type (self-guided *v.* guided), population (community *v.* treatment), and possibly due to sub-optimal user-adherence, which often is the pitfall of digital interventions. Our findings do not align with the two aforementioned studies regarding post-treatment depression effects (Deady et al., 2016; Frohlich et al., 2021). This might be explained by various reasons. First, contrary to our study, both these studies were conducted among non-clinical samples and employed either an attention-control condition or directed participants to alcohol- and mental health-related psychoeducational material (Deady et al., 2016; Frohlich et al., 2021). Both our study trial arms received TAU for depression. Consequently, reductions in depressive symptoms occurred in both groups. Second, based on the literature we hypothesized larger improvements in depressive symptoms in our BtB + TAU group, due to the larger decreases in alcohol use (Charlet & Heinz, 2017). Such an effect was not observed in our data. This aligns with a general population study among adults with depression, in which alcohol use was not found to be a predictor for an unfavorable depression course (Schouten et al., 2023b). Third, AUDIT scores from our study sample were indicative of at least hazardous drinking patterns in the past year, corresponding to the lowest cut-off for the likelihood of moderate AUD (Babor et al., 2001), but remarkably, participants drank on average 16 weekly drinks at baseline, indicating that participants may have already reduced their drinking before the start of treatment, as this is often advised during treatment intakes. Therefore, we may have not captured the full potential beneficial effects of alcohol use reduction on depressive symptoms.

Strengths and limitations

Strengths of this study include an RCT design, tailored digital intervention, relatively long follow-up, and a high study response rate. There are however some limitations to take in account. First, low treatment response rates might be attributed to its operationalization. Treatment response was achieved if all three a-priori defined alcohol and depression criteria were met. Especially the depression criterion (CES-D score <16 or 40% reduction from baseline) appeared not feasible for both BtB + TAU and TAU groups, with only 27.8% and 30.9% meeting this criterion, respectively. Consequently, low treatment response occurred in both trial arms. Second, we recruited participants via traditional trial recruitment (i.e. mental health care sites) and through social media advertisements. Social media trial recruitment has been increasing over the years due to advantages in speed and efficiency. However, there are indications that the representativeness of social media-recruited samples may be more limited, for example in terms of gender, educational level, and higher substance use (Sanchez et al., 2020). Indeed, in our study AUDIT scores were higher for our social media recruitment group. This may indicate that the social media advertisement algorithm mostly reached young adults with severe alcohol problems, or that those young adults were more inclined to participate. Third, depression diagnoses and treatment information from social media-recruited participants were based on self-report and could not be verified through medical records. Fourth, we were able to closely monitor the start of depression treatment for the traditional recruitment group. Hence, baseline assessments could be timed more precisely. Often social media-recruited participants already started treatment during study enrolment. Therefore, we may not have captured remission at the start of treatment and missed the peak in depressive symptoms. Fifth, despite overall low attrition, more loss to follow-up occurred in the intervention group. Lastly, only 19% of the users completed all six modules of the program, 47.3% reached the third module, and 43.2% did not go further the first module. Recent studies have shown that rapid and relevant improvement in depression and anxiety symptoms takes place in the first part of (internet-delivered) psychological treatment (Bisby et al., 2023). Moreover, populations with mild-to-moderate depression and anxiety symptoms require between four and six sessions of low intensity guided self-help for relevant improvement in symptoms (Robinson, Delgadillo, & Kellett, 2020). This shows that 100% completion of modules is not always necessary in order to benefit from digital interventions. Given the potentially different intervention usage preferences, e.g. preference to complete modules *v.* a preference for only self-monitoring alcohol use, future research could focus on developing innovative strategies for increasing adherence – for example through more intensive forms of personal guidance and increasing personalization. We recommend not to aim for a one-size-fits-all approach when designing digital interventions, but to further increase personalization features so that the end-user can tailor the intervention to their needs and preferences. Personalization in digital interventions can for example occur in the type and amount of the intervention content, order of the modules, the type of guidance, and

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type and frequency of automated communication (Hornstein, Zantvoort, Lueken, Funk, & Hilbert, 2023). Larger digital intervention engagement has been associated with greater improvements in mental health symptoms (Gan, McGillivray, Han, Christensen, & Torok, 2021). Therefore, for some end-users improved user-adherence of digital interventions may result in higher treatment benefit.

Conclusion

The tailored add-on digital alcohol intervention for depression treatment was more effective than depression treatment alone in reducing alcohol use after 3- and 6-month follow-up, but not in reducing depressive symptoms and treatment response among young adults with co-occurring depressive disorders and problematic alcohol use.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291724000953.

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

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