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Publication Date

2022-08-01

DOI

10.1016/j.drugalcdep.2022.109532

Peer reviewed



HHS Public Access

Author manuscript

Drug Alcohol Depend. Author manuscript; available in PMC 2022 December 13.

Published in final edited form as:

Drug Alcohol Depend. 2022 August 01; 237: 109532. doi:10.1016/j.drugalcdep.2022.109532.

A Randomized Controlled Trial of Social Media Interventions for Risky Drinking among Adolescents and Emerging Adults

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Abstract

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Purpose: Alcohol use among adolescents and emerging adults is an important public health issue requiring prevention approaches. Herein, we describe outcomes from a randomized controlled trial testing the efficacy of group-based social media interventions targeting risky drinking among youth.

Procedures: Using social media advertisements to screen potential participants, we recruited 955 youth (ages 16–24) reporting recent risky drinking. After completing a baseline assessment, participants were randomized to 8-week secret Facebook group conditions: Social Media Intervention + Incentives for engagement, Social Media Intervention only, and attention-placebo control. Electronic coaches trained in motivational interviewing facilitated interaction in intervention groups. Primary outcomes include past 3-month alcohol use and consequences over 3-, 6-, and 12-month follow-ups. Secondary outcomes include other drug use, consequences, and impaired driving. We also measured intervention engagement and acceptability.

Results: The interventions were well-received, with significantly greater acceptability ratings and engagement in the SMI+I condition relative to other groups. In adjusted analyses, there were no significant differences between interventions and control on alcohol-related outcomes, with all groups showing reductions. Regarding secondary outcomes (70.4% used other drugs), compared to control, the incentivized group reduced other drug use, consequences, and cannabis-impaired driving; the non-incentivized group did not significantly differ from the control condition.

Conclusions: Among this predominantly poly-substance using sample, findings were mixed, with significant effects of the incentive social media intervention on drug (but not alcohol) outcomes. Future studies are needed to further refine social media-delivered interventions to reduce alcohol and other drug use.

Trial Registration: [ClinicalTrials.gov NCT02809586](https://clinicaltrials.gov/ct2/show/study/NCT02809586); University of Michigan HUM#00102242.

Keywords

social media; alcohol; adolescents; emerging adults; intervention

1. Introduction

Risky drinking among adolescents and emerging adults (EAs) remains an important public health problem, with 4.1% of adolescents ages 12–17 and 31.4% of EAs ages 18–25 reporting past-month binge drinking in 2020 [i.e., 4 drinks (females) or 5 drinks (males), (Substance Abuse and Mental Health Services Administration, 2021)], increasing risk for health, academic, and social consequences, and alcohol use disorders (Behrendt et al., 2009; White and Hingson, 2013). Rates of other drug use, particularly cannabis (i.e., 5.9% of adolescents ages 12–17 and 23.1% of EAs ages 18–25 report past-month cannabis use; (Substance Abuse and Mental Health Services Administration, 2021), and simultaneous use of substances is of concern given greater consequences (Patrick et al., 2017; Patrick et al., 2018). Thus, early interventions to reduce risky drinking and other drug use are needed during this developmental period.

Alcohol and other drug use trajectories are influenced by socio-ecological risk and protective factors (e.g., individual: norms, mental health, protective behavioral strategies;

social: peer substance use, peer disapproval of use; (Abadi et al., 2011; Donovan, 2004; Grazioli et al., 2015; Kumar et al., 2002; Marshall, 2014; Mrug et al., 2010; Mrug and McCay, 2012; Patrick and Schulenberg, 2013; Ryan et al., 2010; Song et al., 2012). As described in the prototype willingness model, situational-level factors are important, creating risk conducive environments (Gerrard et al., 2008; Lewis et al., 2018; Lewis et al., 2017). Peer influences on substance use occur in-person (Abadi et al., 2011; Allen et al., 2012; Brechwald and Prinstein, 2011; Burk et al., 2012; Windle, 2000) and online through positive portrayals on social media. For example, posting alcohol images on social media is common (Cook et al., 2012; Huang et al., 2014; Rodriguez et al., 2016; Stoddard et al., 2012), and related to drinking outcomes as seen in a recent meta-analysis (Curtis et al., 2018). Viewing positive drinking content on social media facilitates positive attitudes towards drinking (Litt and Stock, 2011), and alcohol and drug related social media posting habits are associated with greater consumption (Boyle et al., 2016; Huang et al., 2014; Litt and Stock, 2011; Moreno et al., 2016a; Westgate et al., 2014). Therefore, harnessing social media peer influences in a positive manner to reduce risky drinking (and other drug use) is an important direction for interventions.

Youth interact with multiple social media platforms. Among EAs, 70% use Facebook, 71% use Instagram, 65% use Snapchat, 48% use TikTok, and 42% use Twitter (Anderson and Jiang, 2018; Auxier and Anderson, 2021; Perrin and Anderson, 2019; Pew Research Center, 2021). Few interventions have capitalized on social media to address youth's risky drinking or other drug use (Merchant, 2020; Moreno et al., 2016b). In other health areas (e.g., exercise/weight, smoking, human immunodeficiency virus risk reduction/sexual health, mental health), social media interventions (primarily using Facebook) are beneficial ((Alanzi et al., 2018; Bull et al., 2012; Cao et al., 2017; Cavallo et al., 2012; Haines-Saah et al., 2015; Jaganath et al., 2012; Kernot et al., 2013; Naslund et al., 2018; Ramo et al., 2017; Ramo et al., 2018b; Valle et al., 2013; Young et al., 2013). Recent studies delivering substance use interventions via Facebook are emerging, including studies focusing on binge drinking and tobacco use (Ramo et al., 2018a), misuse of prescription opioids (Young, S.D. et al., 2020), and chronic pain patients on opioid therapy (Young et al., 2018).

A critical consideration in any intervention is engagement, which in social media interventions consists of interacting with content (e.g., likes/reactions) and sharing/responding via comments/replies or self-initiated posts/status updates. For example, an exercise-focused social media intervention found that most participants (63%) averaged eight interactions each over 12 weeks (Cavallo et al., 2012). Engagement-based contingency management approaches, offering financial or other incentives (e.g., movie tickets) could be used to enhance engagement (Pfund et al., 2022; Ramo et al., 2015), which may be particularly advantageous for youth less interested in change. As a contribution to the literature, we examined whether the inclusion of contingency management approaches to incentivize engagement in social media interventions would offer advantages above and beyond a social media intervention, alone.

We report findings from a randomized controlled trial (RCT) of two harm reduction focused social media interventions among risky drinking youth, one intervention group that was provided incentives for participation and another without incentives, compared to a

control condition. Our primary outcomes were alcohol use and consequences, and secondary outcomes were other drug use, consequences, and driving under the influence of alcohol or cannabis. We hypothesized that the intervention conditions would have significantly better outcomes than the control, and that the incentivized intervention condition would show the greatest engagement and largest effects.

2. Method

2.1 Design

Youth (ages 16–24) recruited nationally via Facebook and Instagram ads (2017–2019) completed a screening survey. Ads were placed on both sites because users typically have accounts on both sites (which are owned by the same company). Those reporting past 3-month risky drinking were enrolled in a RCT testing the social media groups (see Bonar et al., 2020), delivered by electronic health coaches (e-coaches): incentivized social media intervention, social media intervention only, and attention-placebo control. Baseline and follow-up assessments (3-, 6-, and 12-months) were self-administered online. The University of Michigan Institutional Review Board approved study procedures. A waiver of parental consent was obtained for youth ages 16–20 (age of majority varies by state). A Certificate of Confidentiality was issued from the National Institutes of Health.

2.2 Procedures

The RCT was conducted in 10 waves separated by age (16–20, 21–24 years). Eligibility questions (i.e., past 3-month Alcohol Use Disorders Identification Test – Consumption [AUDIT-C]; (Bush et al., 1998; Chung et al., 2002; Chung et al., 2000); ages 16–17: ≥ 3 females, ≥ 4 males; ages 18–24: ≥ 4 females, ≥ 5 males) were embedded with demographic and substance use questions to mask eligibility criteria. Verification procedures (Bauermeister et al., 2012a; Teitcher et al., 2015) included review for duplicate IP addresses, survey completion times >60 seconds, and a CAPTCHA to prevent bots. Verified, eligible youth completed an online consent and baseline assessment and uploaded a selfie with the current date and time for verification of their Facebook profile. Based on a computer algorithm, participants were randomized to condition, stratified by sex and age group (16–20; 21–24 years), in blocks of 20 ($M=31.8$ participants per Facebook group). To enhance diversity, starting with wave 5, White individuals and females were not invited once pre-set quotas for these groups within the wave were filled. Participants received gift cards for assessments: \$30 (baseline), \$35 (3-month), \$45 (6-month), and \$55 (12-month). Participants in the incentivized condition received \$1.00 for each day they posted text and/or images (i.e., status updates, comments, replies). These interactions were counted by staff weekly and participants were paid weekly via an Amazon gift card.

2.3 Interventions

In alignment with key considerations for social media intervention delivery (Moreno and D'Angelo, 2019), we chose Facebook as the intervention delivery platform because it allows for secret groups (content only viewable to invited members) and content remains viewable over time (versus disappearing like Snapchat); however, intervention content could be delivered in the future on other platforms given the similarity in features (e.g., sharing

user generated text, images, videos). Over 8 weeks, trained bachelor's and master's level e-coaches posted manualized content (housed in shared drive for coaches to access during shifts) and interacted with participants in secret Facebook groups (see see Bonar et al., 2020). Participants were required to agree to a User Safety Agreement, which prohibited posting opportunities to engage in alcohol or other drug use (e.g., parties, selling drugs), offensive material, or advertisements (violations, which only occurred 5 times total, involved deleting the content and privately reminding participants of the User Safety Agreement). E-coaches were trained in Motivational Interviewing (MI; (Miller and Rollnick, 1991; Resnicow and McMaster, 2012) and Cognitive Behavioral Therapy skills (Kadden et al., 2003) and were supervised by licensed clinical supervisors in weekly individual and group supervision. As would be the case in face-to-face therapy, there was no pre-specified formula for responding to participant posts or comments, although coaches were trained to reply using MI strategies in writing including enhancements such as emojis, gifs, or other images.

Identical content was delivered in intervention conditions, with posts focused on upstream motives for alcohol and other drug use using open-ended questions (with memes, gifs, online videos, online articles) and an Elicit-Provide-Elicit framework to prompt responses. Allowing flexibility for current events (e.g., celebrity overdose death), weekly topics included: dealing with stress, what young people do (substance use norms), staying out of trouble, handling tricky situations, free time activities, friends/parents, staying healthy, and getting support. Alcohol was primarily addressed in substance-focused posts, but cannabis and other drugs were also included. Participants could also initiate posts (e.g., daily struggles, life events). To enhance engagement, coaches private messaged or text messaged participants and occasionally tagged participants [via triggered attending (Majchrzak et al., 2013; Moreno and D'Angelo, 2019)] for example, if a post mentioned something related to a prior participant comment the relevant individual would be tagged with a coach prompt. Figure 2 shows example content related to alcohol, drugs, and other topics.

The Crisis Text Line and 911 were permanently displayed in the group cover photo with a reminder that groups were not monitored 24/7. In the event that participants' shared information in the group that might reflect risk for self-harm or other crisis needs (e.g., feeling more depressed, lack of housing/shelter), e-coaches followed a written protocol involving contacting an on-call master's or doctoral-level clinical supervisor who reviewed the post to help determine risk level. In these cases, coaches private messaged participants to express concern and share crisis and mental health/substance use resources. Our protocol also included written steps for contacting participants via phone to assess risk and make any necessary referrals in the case of overt posting about suicidal ideation.

2.3.1 Fidelity.—We adapted codes from the MI Treatment Integrity (MITI) and MI Skills Code (MISC) to assess MI fidelity. Staff coded randomly selected days of each group (e.g., 3 days/week of 56 days/group; including 2,907 e-coach posts (i.e., status updates, comments, replies). Only 3 coach posts were coded as MI non-adherent confronting/persuading; adherent behaviors, affirmations, or support, occurred frequently (1,512 times). Most (91.7%) reflections were complex (50% = “good” per MITI 4.2). The reflection-to-question ratio was good ($M=1.64$, fair=1, good=2 per MITI 4.2). Regarding reliability, we double-

coded randomly selected posts and replies/comments from 8 of 56 days per group [1,407 posts (status updates, replies, comments)]: affirmation/support ($\kappa=0.80$), questions ($\kappa=0.94$), complex reflections ($\kappa=0.79$), and simple reflections ($\kappa=0.25$; occurred rarely, 4.6% of posts). We coded “personal shares” when e-coaches shared a personal experience (e.g., consequences of drinking) to illustrate intervention concepts and encourage interaction ($\kappa=0.84$; 14.8% of posts).

2.4 Attention-Placebo Control Condition

The control group included entertaining content on non-alcohol or drug-related topics (e.g., sports, lifestyle) posted at the same frequency as the intervention groups.

2.5 Measures

2.5.1. Baseline descriptive information.—Descriptive data included socio-demographic factors (Bauermeister et al., 2012b; Bearman et al., 1997; Centers for Disease Control and Prevention, 2005), motivation to reduce drinking [single-item ruler, from 1–10 (Butler et al., 1999)], past 2-week depression and anxiety positive screen [≥ 10 ; Patient Health Questionnaire-8, $\alpha=0.91$ (Kroenke et al., 2009); Generalized Anxiety Disorder-7; $\alpha=0.93$](Spitzer et al., 2006)], and prior mental health and substance use treatment [single items (Bearman et al., 1997)].

2.5.2. Primary outcomes.—The 3-item total AUDIT-C score (Bush et al., 1998; Chung et al., 2002; Chung et al., 2000) was the primary outcome, which used a past 3-month time frame (in parallel to past 3-month drug use items, below). The items include typical frequency (5-point scale: never to 4 or more times/week), typical quantity (assessed via exact quantity and coded to reflect standard AUDIT-C options scale: 1–2, 3–4, 5–6, 7–9, 10 or more), and frequency of binge drinking (4/5 or more drinks per occasion females/males, respectively; 5-point scale: never to daily or almost daily). Next, we used a modified version of the 24-item Brief Young Adult Alcohol Consequences Questionnaire (Kahler et al., 2005) to assess past 3-month consequences (Bonar et al., 2020) with responses coded (none, any) based on original scoring and summed ($\alpha=0.88$).

2.5.3 Secondary outcomes.—Past 3-month other drug use was measured using a sum of frequency items for the following substances: cannabis, heroin, ecstasy/molly, cocaine/crack/methamphetamine, and other illegal drugs (e.g., LSD); and misuse of prescription opioid pain relievers, sleep or anxiety medications, and ADHD medications. Questions (Ali et al., 2013; McNeely et al., 2016) and response options were based on standard items (i.e., 7-point Likert scale: never/none, once a month or less, 2–3 times a month, about once a week, 2–3 times a week, 4–6 times a week, about once a day, more than once a day; (National Institute on Alcohol Abuse and Alcoholism, n.d.) and summed to create a drug use index. We also created a total substance use index by adding the alcohol frequency item (AUDIT-C) with the drug use index.

To assess past 3-month drug use consequences, we modified the 21-item Brief Marijuana Consequences Questionnaire (Simons et al., 2012) to include cannabis and/or other drug use. Responses were coded as (0=none, 1=at least 1 time) and summed ($\alpha=0.93$).

Past 3-month impaired driving was assessed via a modified Young Adult Driving Questionnaire (Donovan, 1993), with 5 items for alcohol-impaired driving summed ($\alpha=0.85$). A separate cannabis-impaired driving item assessed driving within 1 hour of using cannabis. Responses included: 0=Never, 1=1–2 times, 2=3–5 times, 3=6–10 times, 4=10+ times.

2.5.4 Acceptability.—At 3-months, participants rated enjoyment of content, helpfulness of participant interaction, feeling understood by e-coaches on a 5-point Likert scale (“not at all” to “extremely”; coded as % 3 or greater), and whether they would recommend the groups to others (10-point scale, 1=not at all likely to 10=very likely). Those in the SMI+I condition rated whether the incentives encouraged them to visit the groups, enjoyment, and fairness (10-point scale, 1=not at all to 10=very).

2.5.5 Engagement.—Two staff independently counted participants’ posts (i.e., status updates, comments, replies) and likes/reactions. Engagement data was compared between raters, and discrepancies were resolved by a third rater. We computed total engagement counts for each participant.

2.6 Statistical Analyses for Primary Aims

Descriptive data is presented regarding baseline characteristics, acceptability data, and engagement, including differences by interventions and control conditions (i.e., t-tests, chi-square). Next, descriptive data and generalized linear mixed models (GLMMs) are presented to examine efficacy by condition. GLMMs adjust for correlations between data points due to repeated measurements (Agresti, 2002). Within this model, we estimated treatment effects at a given follow-up by controlling for baseline and estimating between-group difference in the follow-up measurement. For significant outcomes, we re-cast these effects as an adjusted Cohen’s D effect size by dividing the estimated regression coefficient by the total unmodeled variance (including both the random effect variance and the residual variance). These analyses included randomization strata (sex and age group) and a random intercept to adjust for the assigned group (e.g., one of thirty) in this individually randomized group treatment trial (National Institutes of Health, n.d.). We used an “intent to treat” approach in which all randomized participants are included in analyses regardless of actual degree of intervention receipt (Kraemer et al., 2002). Primary outcomes included AUDIT-C score and alcohol consequences; secondary outcomes included drug use index, drug consequences, substance use index (alcohol and drugs), and alcohol- and cannabis-impaired driving.

3.0 Results

3.1 Study Recruitment and Enrollment

Among those completing the screening survey, 72.7% were eligible for the RCT based on age and AUDIT-C score (Figure 1). Among the 1,541 sent baseline invitations, 71.0% consented and 955 enrolled in the RCT. Less than 2% of participants did not join their assigned group. Relative to those not enrolled ($n=526$), participants enrolled were significantly more likely to be female (57.4% males enrolled whereas 71.9% of females enrolled; $\chi^2(1)=34.1$, $p<.001$), older age ($M=20.1$, $SD=2.5$ among not-enrolled

vs. $M=20.4$, $SD=2.6$ enrolled); $t(1479)=-2.5$, $p<.05$), and White race (98.3% of invited White individuals enrolled whereas 31.1% of racial minorities enrolled; $\chi^2(2)=935.6$, $p<.001$); Hispanic/Latinx ethnicity was not significantly different (60.9% enrolled, 65.5% not enrolled; $\chi^2(1)=2.28$, $p>.05$). AUDIT-C scores were significantly lower among those enrolled ($M=6.6$, $SD=1.9$) vs. non-enrolled ($M=7.0$, $SD=2.0$); $t(1479)=4.1$; $p<.001$). Follow-up rates at 3-, 6-, and 12-months exceeded 94% for all conditions, with no evidence of differential attrition (Figure 1). At 3-, 6- and 12-month follow-up, those retained did not significantly differ from those lost on any primary alcohol-related outcomes; however, on secondary drug-related outcomes, those lost to follow-up showed greater initial baseline scores than those retained [i.e., drug use index (3M $p<.05$; 6M $p<.05$; 12M $p<.01$), substance use index (3M $p<.05$; 12M $p<.05$), consequences (3M $p<.05$; 6M $p<.05$; 12M $p<.05$), drugged driving (only at 12M $p<.01$)].

3.2 Sample Characteristics

Sample characteristics were not significantly different by condition (Table 1). Participants were 54.5% female, with a mean age of 20.4 and 62.6% were White; 20.2% were Hispanic/Latinx. Over 95% were single, 61.9% identified as heterosexual, few (3.9%) had children, and most lived with parents (41.7%) or friends (37.3%). Almost two-thirds (64.9%) reported at least some college. More than a third screened positive for significant depression or anxiety; 53.4% and 6.4% had prior mental health and substance use treatment, respectively. Low rates of substance use treatment history may reflect lower severity of substance use in the sample, and are consistent with national rates of treatment utilization (Grant et al., 2015). Most (70.4%) reported other substance use. Participants who reported only using alcohol had lower baseline AUDIT-C scores than those with poly-substance use ($M=6.1$, $SD=1.8$ vs. $M=6.8$, $SD=1.9$, $t(953)=-5.1$; $p<.0001$).

3.3. Acceptability and Engagement

Participants typically rated the SMI+I higher than the SMI, and control (Table 2). The incentives in the incentivized condition were perceived as fair ($M=8.8$; $SD=1.8$) and perceived as increasing group engagement ($M=7.8$; $SD=2.6$), and enjoyable ($M=8.9$; $SD=1.8$). Quantitative data showed that engagement significantly varied by condition (Table 2), with greater engagement in the incentivized condition vs. control and vs. the social media intervention-only, and in the social media intervention-only vs. control, with the exception that likes/reactions were similar in the social media intervention-only and control groups.

3.4 Main Effects on Primary Alcohol Outcomes

There were no significant baseline differences in alcohol variables; descriptively, all conditions declined over time (Table 3). In adjusted models (Table 4), there were no significant effects of either intervention group versus the control group, for any alcohol outcome at 3-, 6- and 12-month follow-up. [Note, we also examined these models using alcohol consumption assessed with an online Timeline Follow-back (TLFB) and these findings/conclusions did not differ; data available upon request. (Hjorthøj et al., 2012; Pedersen et al., 2012; Sobell et al., 1979).]

3.5 Main Effects on Secondary Outcomes

Table 3 displays changes over time in secondary outcomes, with no significant baseline differences by group. The drug use index and substance use index (inclusive of alcohol and drugs). In adjusted models (Table 4), the incentivized group showed significantly greater declines than the control group on the drug use index at 3- and 6-months (Cohen's $d = -0.25$ and -0.25 , respectively). Similarly, the incentivized group showed significantly greater declines in drug consequences than the control at 6-months (Cohen's $d = -0.19$). However, the social media intervention-only and control groups did not significantly differ on drug outcomes. Finally, the incentivized group showed significantly greater declines than the control group on the substance use index at 3- and 6-months [Cohen's $d = -0.22$ and -0.25 , respectively].

Alcohol-impaired driving and cannabis-impaired driving over time are shown in Table 3. In adjusted models (Table 4), there were no significant effects of either intervention versus the control group for alcohol-impaired driving. The incentivized group was significantly lower on cannabis-impaired driving compared to control at 6- and 12-months (Cohen's $d = -0.25$ and -0.23 , respectively), with no significant differences for the social media intervention-only group relative to the control.

4.0 Discussion

Results from our RCT using social media to deliver substance use interventions among youth yielded mixed findings for efficacy, with the intervention group that received incentives for engagement significantly reducing drug-related outcomes relative to the control condition; however, intervention effects on alcohol-related outcomes were not significantly different, as both intervention and control groups reduced alcohol consumption and consequences by 20–30%. There are several nuances to consider in these findings that may inform future directions.

An advantage of social media-based interventions is that they can be tailored in real-time to address other drug use, which was important because although our study eligibility criterion was risky alcohol use, co-use of drugs was more common than anticipated (>70% used cannabis or other drugs at baseline), with past-month cannabis use among EAs rising significantly during the study period (Substance Abuse and Mental Health Service Administration, 2021). A promising finding is that the incentivized social media intervention reduced the secondary outcomes of drug use frequency, drug-related consequences, and drugged driving relative to the attention-control condition, whereas the condition without incentives had no significant effects. This finding may reflect dose, as participants in the incentivized group had about double the engagement of the non-incentivized group. This finding may also reflect the saliency of drug-related posts in a primarily alcohol-focused intervention, and/or the severity of consequences noted by participants and/or coaches for drug use (e.g., overdose), which seemed to be more severe than for alcohol (e.g., hangovers). One caveat is that not all interaction was positive; occasionally a participant posted sarcastic or pro-substance use comments which may have been more diluted in the incentivized condition with greater engagement. Alternatively, it may be that the incentive condition empowered youth to be change agents or helpers for others in the group to reduce drug use.

This explanation is consistent with the prototype willingness model (Lewis et al., 2017), in which the e-coaches created social contexts toward reducing drug use, eliciting peers to post negative consequences of drug use and harm reduction strategies to reduce consequences, potentially influencing other's willingness to use drugs. Future examination of the content of group interactions is needed to explore these suppositions as the type of interactions likely matters (Young, L.E. et al., 2020; Young et al., 2014).

In contrast, as noted above, alcohol consumption and consequences appeared to decrease over time in all conditions, potentially reflecting natural reductions in alcohol use among young people, or demand characteristics related to completing detailed assessments about alcohol-related factors. Results may also reflect a placebo effect given that all youth were invited to join a social media group, and/or the repeated assessments of alcohol consumption over time may have caused some degree of assessment reactivity. Further, at 12-months, on average alcohol use was relatively modest (e.g., AUDIT-C score of 4.8), however, in the context of individual heterogeneity in consumption and continued consequences, interventions to prevent escalation to alcohol use disorders are warranted. Future analysis is needed to explore sub-groups who may have been more or less likely to respond to the interventions, as those with higher alcohol severity may need additional individually focused interventions.

Given promising effects on drug use, future studies should continue evaluating group interventions using social media. Secret Facebook groups offer some advantages over other platforms, allowing asynchronous group interaction, which overcomes a barrier of video-based group therapy or in-person programs requiring schedule alignment. Unlike other technology-based interventions which require funding for software updates, this intervention is delivered on an existing platform which is continually updated. If this social media intervention were to be integrated into health systems, the content could be delivered via other online chat rooms; however, social media does offer the advantage of frequent utilization. Staffing via bachelor's-level e-coaches (the majority of our staff) provides a lower cost alternative, and potentially more relatable coaches, for scalable delivery potentially as part of medical care or education efforts (e.g., college student orientation, alcohol violations). Although given the novelty of our research we had staff monitor and post in the intervention groups multiple times per day, newer features of social media allow advanced post scheduling, which could enhance feasibility of implementation (reducing need for staffing on nights/weekends). Importantly, potential risk situations due to posts from participants were low (10 occurrences across 20 intervention groups: 4 phone contacts with a single participant with suicidal ideation; 2 private messages to participants about mixing substances; and 4 private messages to participants with resources for acute struggles). These qualitative data support this notion that lower levels of staffing could occur outside of the research context, which is consistent with standard clinical care via patient portals (with the Crisis Text Line pinned to the page with notation not being monitored 24/7). As payers are increasingly covering virtual therapy throughout the COVID-19 pandemic, the proposed intervention could be part of reimbursable services for youth who use drugs, which would be critical for dissemination. Understanding costs and benefits of incentives is necessary to inform implementation efforts, with a maximum of \$56 paid per

person being a relatively low-cost reinforcer magnitude for engagement-based contingency management (Pfund et al., 2022).

Several limitations should be mentioned. Prior work suggests that online samples are similar to national surveys (Bauermeister et al., 2012b); however, sample representativeness is unclear. Although racial and ethnic minorities were oversampled, difficulty was encountered enrolling males. Future papers exploring subgroups based on race or ethnicity, or other subgroups (e.g., sex, age) could inform future intervention work, including examination of outcomes for sexual and gender minorities. While objective biomarkers may enhance the evaluation of trial outcomes, it was not feasible to collect such data in this large, national sample with a trial conducted fully online. Thus, our outcomes included self-report of substance use; however, computer administration with privacy protections enhances reliability and validity.

We used the AUDIT-C score to parallel the drug use assessment (and the alcohol findings were comparable using the TLFb); alternatively, finer grained and more frequent assessments (e.g., daily or weekly surveys) may have greater precision in identifying changes over time. Next, it is possible that social desirability bias or assessment reactivity (given the number of alcohol focused questions) could explain alcohol reductions in intervention and control conditions. Given the novelty of the interventions tested in this study, replication is recommended, as well as future analyses identifying mediators and moderators of outcomes, possible sub-groups with potential effects on alcohol outcomes, and content of group interactions in relation to outcomes.

4.2 Conclusions

Despite limitations, results suggest that a modestly incentivized social media-based, group-delivered intervention reduced drug use, consequences, and drugged driving, but paradoxically did not reduce alcohol misuse among youth. Incentives appear helpful in enhancing engagement and efficacy for reducing drug-related outcomes, which has implications for future implementation with research supporting the cost-effectiveness of contingency management approaches (Belendiuk and Riggs, 2014; Olmstead and Petry, 2009). Given that our manualized content could be delivered across other platforms with ease, replication and refinement of social media interventions for drug use are warranted. Future analyses will further examine group interactions and individual characteristics to inform potential intervention adaptations based on individual response over time (Lei et al., 2012).

Acknowledgements:

Funding was provided by a grant from the National Institute on Alcohol Abuse and Alcoholism (NIAAA) R01AA024175. LNCs time was funded by NIAAA K23AA028232 and ARFs time was funded by NIAAA T32AA007477. AKD was supported by T32AA007477 and is also supported by private philanthropic funding from Tim Ferriss, Matt Mullenweg, Craig Nerenberg, Blake Mycoskie, the Steven and Alexandra Cohen Foundation, and by the Center for Psychedelic Drug Research and Education, funded by anonymous private donors. These funders had no role in the design, execution, or delivering the findings of this study.

Conflicts of Interest:

The authors do not have any personal financial interests related to this manuscript, with 2 exceptions. MW is a minor shareholder in Facebook and has a conflict-of-interest plan approved by the University of Michigan. SY has received an unrestricted gift from Facebook, on file with the University of California, Irvine.

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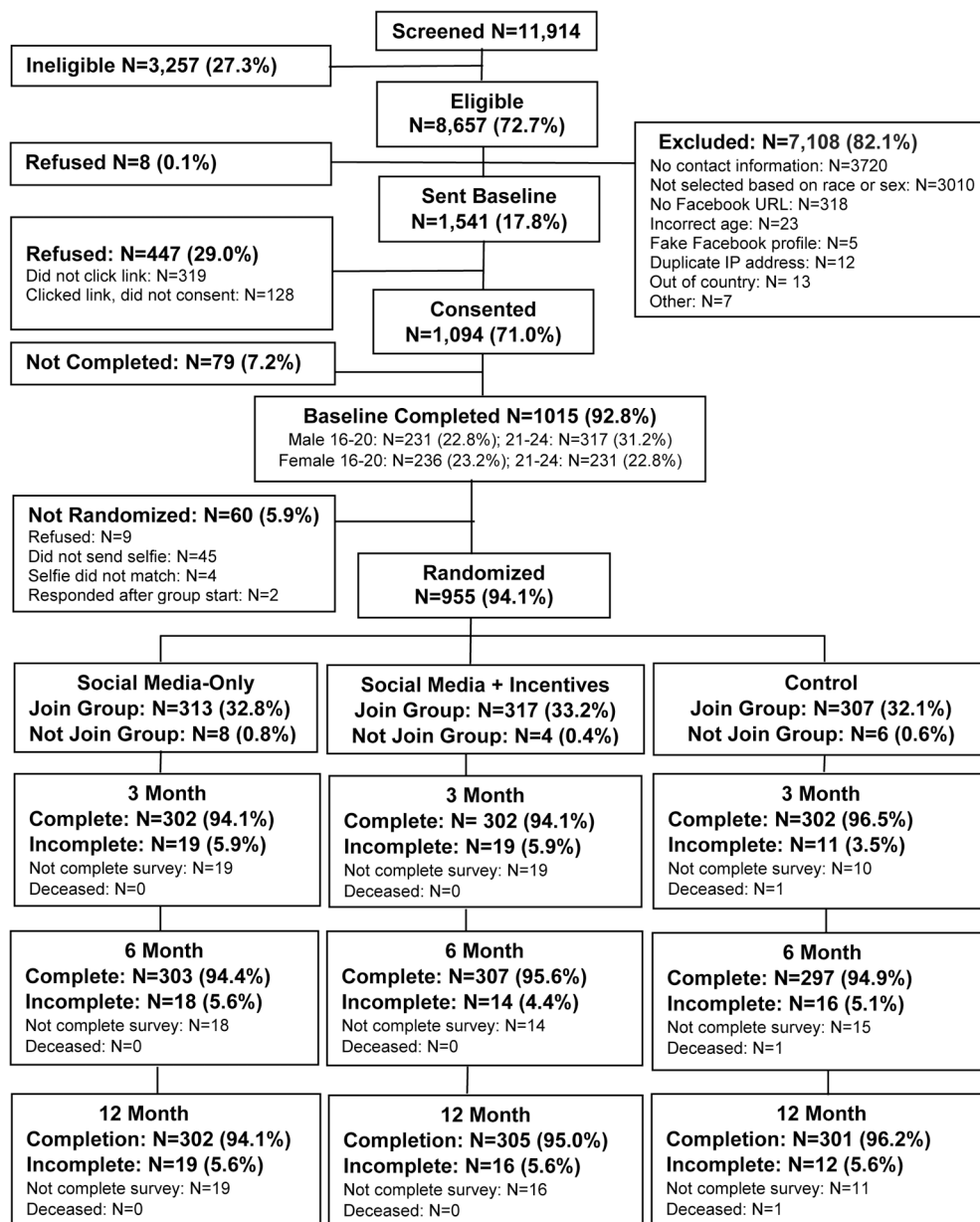


Figure 1:
Study Flowchart (1/2017 – 6/2020)

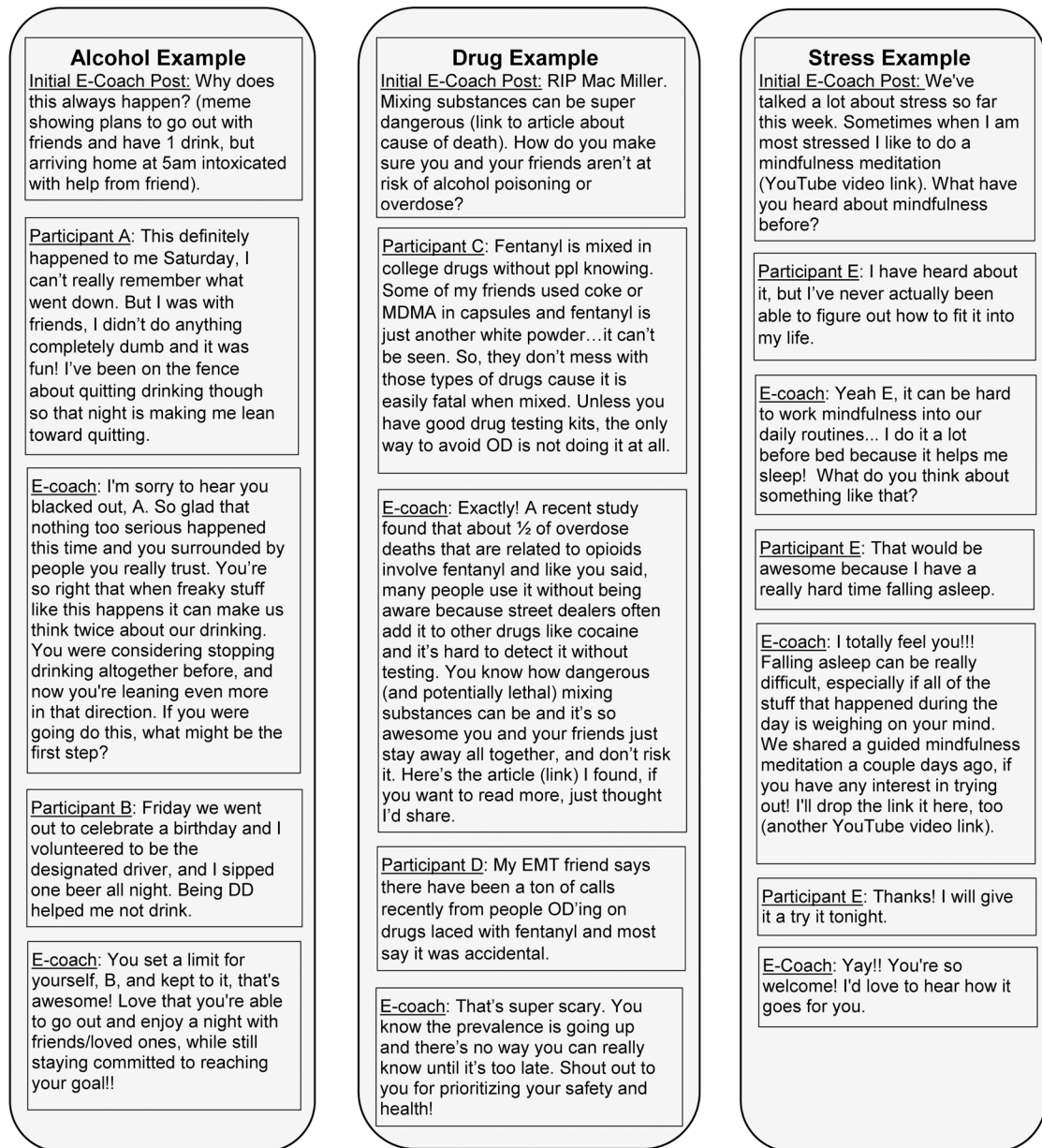


Figure 2:
 Examples of content across different domains and redacted participant and e-coach interactions

Table 1.

Sample characteristics of risky drinkers by condition

Variable	Social Media Intervention- Only (n= 321) M (SD)/N (%)	Social Media Intervention+ Incentives (n= 321) M (SD)/N (%)	Control (n= 313) M (SD)/N (%)	Total (n=955) M (SD)/N (%)
Age	20.5 (2.6)	20.3 (2.6)	20.5 (2.6)	20.4 (2.6)
Female sex	175 (54.5%)	174 (54.2%)	171 (54.6%)	520 (54.5%)
Race				
White only	190 (59.2%)	203 (63.2%)	205 (65.5%)	598 (62.6%)
Black only	43 (13.4%)	45 (14.0%)	31 (9.9%)	119 (12.5%)
Black multi-racial	20 (6.2%)	23 (7.2%)	22 (7.0%)	65 (6.8%)
Asian only	18 (5.6%)	20 (6.2%)	13 (4.2%)	51 (5.3%)
Other races	50 (15.8%)	30 (9.4%)	42 (13.4%)	122 (12.8%)
Hispanic/Latinx ethnicity	72 (22.4%)	63 (19.6%)	58 (18.5%)	193 (20.2%)
Marital status: Single	307 (95.6%)	308 (96.0%)	296 (94.6%)	911 (95.4%)
Highest education: Any college or more	213 (66.4%)	191 (59.5%)	213 (68.1%)	617 (64.6%)
Has children	11 (3.4%)	13 (4.1%)	13 (4.2%)	37 (3.9%)
Individual income ^a				
< \$15,000	161 (57.9%)	144 (54.1%)	164 (58.6%)	469 (56.9%)
\$15000–25,000	40 (14.4%)	46 (17.3%)	39 (13.9%)	125 (13.9%)
\$25,000–34,999	26 (9.4%)	28 (10.5%)	27 (9.6%)	81 (9.8%)
\$35,000–49,999	24 (8.6%)	19 (7.1%)	21 (7.5%)	64 (7.8%)
\$50,000 or more	27 (9.7%)	29 (10.9%)	29 (10.4%)	85 (10.3%)
Parent income ^b				
< \$25000	60 (21.8%)	55 (19.9%)	43 (16.0%)	158 (19.3%)
\$25000–49,999	60 (21.8%)	55 (19.9%)	61 (22.7%)	176 (21.5%)
\$50,000–99,999	71 (25.8%)	70 (25.4%)	78 (29.0%)	219 (26.7%)
\$100000 or more	84 (30.6%)	96 (34.8%)	87 (32.2%)	267 (32.6%)
Sexual orientation				
Gay/lesbian/same gender	34 (10.6%)	26 (8.1%)	17 (5.4%)	77 (8.1%)
Bisexual	76 (23.7%)	70 (21.8%)	74 (23.6%)	220 (23.0%)
Straight	190 (59.2%)	206 (64.2%)	195 (62.3%)	591 (61.9%)
Queer or other identities	21 (6.5%)	19 (5.9%)	27 (8.6%)	67 (7.0%)
Mental health and drug use				
Positive anxiety screen ^c	125 (38.9%)	137 (42.7%)	123 (39.3%)	385 (40.3%)
Positive depression screen ^c	131 (40.8%)	126 (39.3%)	117 (37.4%)	374 (39.2%)
Mental health treatment history	171 (53.3%)	179 (55.8%)	160 (51.1%)	510 (53.4%)
Cannabis use	206 (64.2%)	195 (60.8%)	200 (63.9%)	601 (62.9%)
Other illicit drug use	67 (20.9%)	68 (21.2%)	66 (21.1%)	201 (21.0%)
Prescription drug misuse	82 (25.6%)	87 (27.1%)	76 (24.3%)	245 (25.7%)
Motivation to change ^d	2.9 (2.5)	2.9 (2.3)	2.8 (2.3)	2.9 (2.4)

Variable	Social Media Intervention- Only (n= 321) M (SD)/N (%)	Social Media Intervention+ Incentives (n= 321) M (SD)/N (%)	Control (n= 313) M (SD)/N (%)	Total (n=955) M (SD)/N (%)
Substance use treatment history	24 (7.5%)	22 (6.9%)	15 (4.8%)	61 (6.4%)

Note:

^aRemoved n=131 “don’t know”;

^bRemoved n=135 “don’t know”;

^cmoderate ≥ 10 ;

^d1–10 ruler

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Table 2.

Acceptability and engagement by condition.

Variable	Social Media Intervention+ Incentives N=321 M (SD) / %	Social Media Intervention-Only N=321 M (SD) / %	Control N=313 M (SD) / %
<u>Content Ratings</u>			
Memes ^{***a, b, c}	84.7%	75.9%	65.9%
News articles ^{***a, b, c}	85.7%	78.5%	59.7%
Quizzes ^{***a, b, c}	82.1%	75.7%	54.2%
<u>Coach Ratings</u>			
Helpfulness ^{***a, c}	86.0%	77.6%	65.2%
Feeling understood ^{***a, b, c}	85.7%	76.6%	61.1%
Warmth ^{***a, b}	93.6%	96.0%	81.1%
Respect ^{***a, b}	97.3%	98.3%	92.2%
<u>Group ratings</u>			
Helpfulness of peer interaction ^{***a, b, c}	79.7%	67.8%	46.3%
Recommend group to others ^{***a, b, c}	7.4 (2.76)	6.2 (2.8)	5.3 (3.2)
<u>Engagement</u>			
Posts (status, comments) ^{***a, b, c}	38.8 (31.8)	18.3 (22.7)	3.9 (9.0)
Likes/reactions ^{***a, c}	27.0 (40.7)	14.5 (24.8)	12.4 (25.2)
Total posts + likes/reactions ^{***a, b, c}	65.8 (65.5)	32.8 (42.9)	16.4 (29.9)

Note: Ratings coded as % indicating 3 or greater on a 5-point scale.

*
 $p < 0.05$,**
 $p < 0.01$ and***
 $p < 0.001$ (overall variable comparison)^a Social Media Intervention + Incentives vs. Control;^b Social Media Intervention-Only vs. Control;^c Social Media Intervention + Incentives vs. Social Media Intervention-Only (all contrasts: $p < .05$)

Table 3.

Mean (SD) and changes over time since baseline in primary and secondary outcomes

Outcome Variable	Baseline	3 Months	% Change	6 Months	% Change	12 Months	% Change
AUDIT-C score							
Social Media Only	6.7 (1.8)	5.3 (2.6)	-20.9%	5.2 (2.6)	-22.4%	4.9 (2.6)	-26.9%
Social Media + Incentives	6.4 (2.0)	5.2 (2.7)	-18.8%	5.0 (2.7)	-21.9%	4.8 (2.7)	-25.0%
Control	6.7 (1.9)	5.1 (2.6)	-23.9%	5.1 (2.7)	-23.9%	4.8 (2.6)	-28.4%
Binge Drinking							
Social Media Only	2.2 (0.8)	1.7 (1.1)	-22.7%	1.6 (1.1)	-27.3%	1.5 (1.1)	-31.8%
Social Media + Incentives	2.1 (0.8)	1.6 (1.1)	-23.8%	1.5 (1.1)	-28.6%	1.6 (1.1)	-23.8%
Control	2.1 (0.8)	1.6 (1.1)	-23.8%	1.6 (1.1)	-23.8%	1.5 (1.1)	-28.6%
Alcohol consequences							
Social Media Only	8.7 (5.2)	6.7 (5.6)	-23.0%	6.2 (5.6)	-28.7%	5.7 (5.7)	-34.5%
Social Media + Incentives	8.7 (5.2)	6.7 (5.4)	-23.0%	6.2 (5.2)	-28.7%	5.7 (5.1)	-34.5%
Control	9.0 (5.9)	6.7 (5.7)	-25.6%	6.2 (5.8)	-31.1%	5.5 (5.6)	-38.9%
Drug use index							
Social Media Only	3.0 (3.3)	2.6 (3.1)	-13.3%	2.4 (3.0)	-20.0%	2.7 (3.4)	-10.0%
Social Media + Incentives	3.1 (3.7)	2.5 (3.1)	-19.4%	2.4 (3.0)	-22.6%	2.6 (3.1)	-16.1%
Control	3.1 (3.5)	3.0 (3.6)	-3.2%	2.9 (3.5)	-6.5%	3.0 (3.4)	-3.2%
Drug consequences							
Social Media Only	4.1 (5.2)	3.2 (4.7)	-22.0%	2.8 (4.4)	-31.7%	3.0 (4.7)	-26.8%
Social Media + Incentives	3.6 (5.0)	2.8 (4.4)	-22.2%	2.5 (3.9)	-30.6%	2.8 (4.6)	-22.2%
Control	3.6 (4.7)	3.1 (4.6)	-13.9%	3.1 (4.6)	-13.9%	3.3 (5.1)	-8.3%
Substance use index							
Social Media Only	5.6 (3.5)	4.9 (3.3)	-12.5%	4.7 (3.2)	-16.1%	4.9 (3.6)	-12.5%
Social Media + Incentives	5.8 (3.9)	4.9 (3.4)	-15.5%	4.7 (3.3)	-18.9%	4.8 (3.3)	-17.2%
Control	5.8 (3.7)	5.3 (3.9)	-8.6%	5.2 (3.8)	-10.3%	5.2 (3.5)	-10.3%
Alcohol-impaired driving							
Social Media Only	1.6 (2.5)	1.4 (2.6)	-12.5%	1.2 (2.3)	-25.0%	1.2 (2.4)	-25.0%
Social Media + Incentives	1.6 (3.1)	1.4 (2.9)	-12.5%	1.2 (2.5)	-25.0%	1.2 (2.6)	-25.0%
Control	1.5 (2.5)	1.5 (2.7)	-0.0%	1.2 (2.3)	-20.0%	1.2 (2.7)	-20.0%
Cannabis-impaired driving							
Social Media Only	0.5 (1.1)	0.5 (1.1)	-0.0%	0.5 (1.1)	0.0%	0.4 (1.0)	-20.0%
Social Media + Incentives	0.6 (1.2)	0.5 (1.1)	-16.7%	0.4 (1.0)	-33.3%	0.4 (0.9)	-33.3%
Control	0.6 (1.2)	0.6 (1.2)	-0.0%	0.6 (1.2)	-0.0%	0.6 (1.2)	-0.0%

Table 4.

Results of general linear mixed models for primary and secondary outcomes.

Outcomes	Variable	3M Estimate (SE)	p-value	6M Estimate (SE)	p-value	12M Estimate (SE)	p-value
AUDIT-C score	Baseline	0.64 (0.04) ***	<0.0001	0.56 (0.04) ***	<0.0001	0.49 (0.05) ***	<0.0001
	Sex	-0.56 (0.16) ***	0.0004	-0.37 (0.17) *	0.0306	-0.31 (0.17)	0.0707
	Age group	-0.56 (0.15) ***	0.0002	0.05 (0.17)	0.7500	-0.33 (0.17) *	0.0460
Binge drinking	Social Media-Only	0.11 (0.18)	0.5262	0.07 (0.20)	0.7388	0.01 (0.20)	0.9429
	Social Media + Incentives	0.19 (0.18)	0.2982	0.01 (0.20)	0.9812	0.12 (0.20)	0.5371
	Baseline	0.60 (0.04)	<0.0001	0.55 (0.04)	<0.0001	0.49 (0.04)	<0.0001
Alcohol consequences	Sex	-0.21 (0.06) **	0.0010	-0.16 (0.07) *	0.0181	-0.12 (0.07)	0.0987
	Age group	-0.18 (0.06) **	0.0045	0.07 (0.08)	0.3538	-0.08 (0.07)	0.2293
	Social Media-Only	0.02 (0.08)	0.7430	-0.04 (0.09)	0.6864	0.01 (0.08)	0.8910
Drug use index	Social Media + Incentives	0.03 (0.08)	0.6517	-0.04 (0.09)	0.6616	0.13 (0.08)	0.1287
	Baseline	0.64 (0.03) ***	<0.0001	0.54 (0.03) ***	<0.0001	0.49 (0.03) ***	<0.0001
	Sex	-0.67 (0.29) *	0.0199	-0.74 (0.31) *	0.0181	0.22 (0.32)	0.4949
Drug consequences	Age group	-0.67 (0.29) *	0.0203	0.32 (0.33)	0.3377	-0.02 (0.36)	0.9515
	Social Media-Only	0.19 (0.35)	0.5907	0.20 (0.41)	0.6205	0.38 (0.44)	0.3877
	Social Media + Incentives	0.14 (0.35)	0.6791	0.18 (0.40)	0.6576	0.37 (0.44)	0.3991
Drug use index	Baseline	0.72 (0.02) ***	<0.0001	0.62 (0.02) ***	<0.0001	0.57 (0.03) ***	<0.0001
	Sex	-0.43 (0.14) **	0.0021	-0.01 (0.15)	0.9471	0.21 (0.17)	0.2311
	Age group	0.21 (0.16)	0.2110	0.42 (0.22)	0.0530	0.76 (0.22) **	0.0005
Drug consequences	Social Media-Only	-0.32 (0.20)	0.1114	-0.45 (0.27)	0.0894	-0.24 (0.27)	0.3698
	Social Media + Incentives	-0.53 (0.20) **	0.0081	-0.58 (0.27) *	0.0310	-0.44 (0.26)	0.0941
	Baseline	0.63 (0.02) ***	<0.0001	0.53 (0.02) ***	<0.0001	0.50 (0.03) ***	<0.0001
Drug consequences	Sex	-0.14 (0.22)	0.5397	-0.27 (0.23)	0.2315	-0.05 (0.27)	0.8550
	Age group	0.14 (0.28)	0.6118	0.26 (0.23)	0.2622	0.92 (0.31) **	0.0031
	Social Media-Only	-0.07 (0.34)	0.8345	-0.49 (0.28)	0.0800	-0.45 (0.37)	0.2305
Social Media + Incentives	-0.34 (0.34)	0.3163	-0.65 (0.28) *	0.0193	-0.55 (0.14)	0.1373	

Outcomes	Variable	3M Estimate (SE)	p-value	6M Estimate (SE)	p-value	12M Estimate (SE)	p-value
Substance use index	Baseline	0.72 (0.02) ***	<0.0001	0.62 (0.02) ***	<0.0001	0.55 (0.03) ***	<0.0001
	Sex	-0.53 (0.16) ***	0.0008	-0.03 (0.17)	0.8820	0.17 (0.19)	0.3619
	Age group	0.10 (0.19)	0.5867	0.46 (0.23) *	0.0436	0.65 (0.22) **	0.0033
	Social Media-Only	-0.32 (0.23)	0.1612	-0.46 (0.28)	0.1014	-0.25 (0.27)	0.3570
	Social Media + Incentives	-0.53 (0.23) *	0.0198	-0.65 (0.28) *	0.0205	-0.49 (0.27)	0.0686
Alcohol-impaired driving	Baseline	0.63 (0.03) ***	<0.0001	0.48 (0.02) ***	<0.0001	0.46 (0.03) ***	<0.0001
	Sex	-0.34 (0.14) *	0.0160	-0.29 (0.13) *	0.0241	-0.28 (0.15)	0.0553
	Age group	-0.21 (0.16)	0.1952	-0.24 (0.16)	0.1390	-0.33 (0.16) *	0.0353
Cannabis-impaired driving	Social Media-Only	-0.18 (0.19)	0.3369	-0.00 (0.19)	0.9860	-0.06 (0.19)	0.7623
	Social Media + Incentives	-0.18 (0.19)	0.3450	-0.08 (0.19)	0.6651	-0.16 (0.19)	0.3879
	Baseline	0.68 (0.02) ***	<0.0001	0.58 (0.02) ***	<0.0001	0.51 (0.02) ***	<0.0001
	Sex	-0.06 (0.06)	0.2520	-0.10 (0.06)	0.0903	0.00 (0.06)	0.9921
	Age group	0.04 (0.06)	0.4749	0.13 (0.06) *	0.0387	0.07 (0.08)	0.3625
	Social Media-Only	-0.03 (0.07)	0.6993	-0.10 (0.07)	0.1681	-0.09 (0.09)	0.3403
	Social Media + Incentives	-0.11 (0.07)	0.1051	-0.22 (0.07) **	0.0037	-0.20 (0.09) *	0.0296

Note: Sex coded: Female (0); Male (1). Age group coded: 16–20; 21–24. “Baseline” in each model refers to the baseline value of the dependent measure.

* $p < 0.05$,

** $p < 0.01$ and

*** $p < 0.001$