JAMA Network Open

Original Investigation | Pediatrics

A Digital Behavioral Health Game for Adolescent Mental Health
A Prespecified Secondary Analysis of a Randomized Clinical Trial

Caroline M. Barry, PhD, MPH; Tyra Boomer, MEM; Katie Haile, MPH; Haiyi Xie, PhD; Lynn E. Fiellin, MD

Abstract

IMPORTANCE Adolescent depression and anxiety are common and impairing conditions. Scalable, engaging digital interventions offer a low-burden strategy to support youth mental health.

OBJECTIVE To evaluate the association of a codesigned digital behavioral health game for adolescents with depressive and anxiety symptoms during 12 months of follow-up and to explore the association with psychosocial outcomes.

DESIGN, SETTING, AND PARTICIPANTS This prespecified secondary analysis of a randomized clinical trial included assessments from baseline through 12 months. Eligible adolescents from 15 school-based health programs in Connecticut were 16 to 19 years of age and reported past 30-day use of alcohol, cannabis, vaping, or other nonopioid substances or elevated depression and/or anxiety symptoms. Participants were enrolled between October 21, 2021, and February 27, 2024; data analyses were completed on November 12, 2025.

INTERVENTION Participants were randomized 1:1 to a digital game of approximately 300 minutes delivered during 6 weeks or to an attention-matched active control.

MAIN OUTCOMES AND MEASURES Prespecified secondary outcomes included depressive (8-item Patient Health Questionnaire [PHQ-8]) and anxiety (7-item Generalized Anxiety Disorder [GAD-7]) symptoms. Psychosocial outcomes included beliefs about psychological services (BAPS), help-seeking intentions, and emotion regulation. Linear mixed models with participant-level random intercepts tested group, time, and group-by-time effects. Moderation by baseline characteristics and exploratory mediation of PHQ-8 scores via BAPS were examined.

RESULTS Among 532 participants, 269 were randomized to the intervention and 263 to the control condition; 284 (53.4%) were male, with a mean (SD) age of 16.6 (0.7) years. A group-by-time interaction was observed for PHQ-8 scores ($F_{3,1308}$ = 2.93; P = .03). At 12 months, adjusted mean PHQ-8 scores were 5.30 (95% CI, 4.74-5.86) in the intervention group and 6.42 (95% CI, 5.86-6.98) in the control group (adjusted difference, −1.12 [95% CI, −1.85 to −0.38] points), with no association detected for GAD-7. At 6 weeks, intervention participants reported higher BAPS scores (adjusted difference, 0.03 [95% CI, 0.01-0.05]). Exploratory mediation showed that early BAPS improvements were associated with PHQ-8 score reductions at 6 months. No associations with remaining outcomes or moderation were observed.

CONCLUSIONS AND RELEVANCE In this prespecified secondary analysis of a randomized clinical trial, the intervention was associated with modest, sustained reductions in depressive symptoms during 12 months of follow-up. Early improvements in BAPS showed associations consistent with

(continued)

Key Points

Question Is a codesigned digital behavioral health game for adolescents associated with reduced depressive and anxiety symptoms during 12 months of follow-up?

Findings In this prespecified secondary analysis of a randomized clinical trial of 532 adolescents, the digital behavioral health game was associated with a significant reduction in depressive symptoms compared with an active control during 12 months of follow-up, whereas no association was observed for anxiety symptoms. The intervention was also associated with improved beliefs about psychological services immediately after the intervention, which partially explained short-term depressive symptom reductions.

Meaning A codesigned digital behavioral health game may offer a scalable approach to improving adolescent mental health.

+ Visual Abstract

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

Abstract (continued)

mediation of short-term depressive symptom reductions. Digital games may support adolescent mental health at scale.

TRIAL REGISTRATION ClinicalTrials.gov Identifier: NCT04941950

JAMA Network Open. 2026;9(8):e2629173. doi:10.1001/jamanetworkopen.2026.29173

Introduction

The rates of depression and anxiety have risen sharply, and these conditions are among the most prevalent adolescent health conditions in the US.[1] Approximately 1 in 5 youths experience depressive symptoms, and 1 in 5 experience anxiety symptoms.[2] According to a 2024 report by the Substance Abuse and Mental Health Services Administration, in the past year, more than 2.5 million adolescents (10.1%) experienced serious suicidal ideation, 1.2 million (4.6%) made a suicide plan, and 700 000 (2.7%) attempted suicide.[3] However, access to timely, appropriate mental health care remains limited. Scalable prevention approaches delivered in school and community settings have immense promise as upstream solutions.[4] Such interventions may narrow the treatment gap by providing earlier, lower-intensity support to youth who may not otherwise access care.[5,6]

Digital interventions are highly scalable. Serious games for purposes beyond entertainment[7] leverage digital environments where youths already immerse themselves to promote healthy attitudes, intentions, and behaviors.[8-12] These games can embed skill building and psychoeducation within interactive narratives, potentially enhancing motivation and reducing perceived stigma associated with help-seeking. However, evidence regarding longer-term mental health effects among adolescents is limited, especially from randomized trials with active controls and follow-up beyond immediate post intervention.[13,14]

A digital behavioral health game (PlaySmart; Playbl) was codesigned with youths[9] that integrates narrative decision-making and peer-interaction scenarios to strengthen protective mental health processes, including emotion awareness, problem solving, and positive beliefs about seeking psychological support. The game was created to prevent opioid misuse and promote mental health.[9,15-18] Effects on perceived risk of harm of opioid misuse and other opioid-related outcomes have been previously reported.[19]

We conducted a secondary analysis of a randomized clinical trial (RCT) that tested the effects of assignment to the intervention compared with a control group assigned to attention-matched commercial games on depressive and anxiety symptoms during 12 months of follow-up among adolescents recruited from school-based health programs (SBHPs).[18] Other outcomes included beliefs about psychological services (BAPS), help-seeking intentions, and emotion regulation. We hypothesized that the intervention game would be associated with reduced depressive and anxiety symptoms and improved BAPS, help-seeking intentions, and emotion regulation compared to active control.

Methods

Study Population

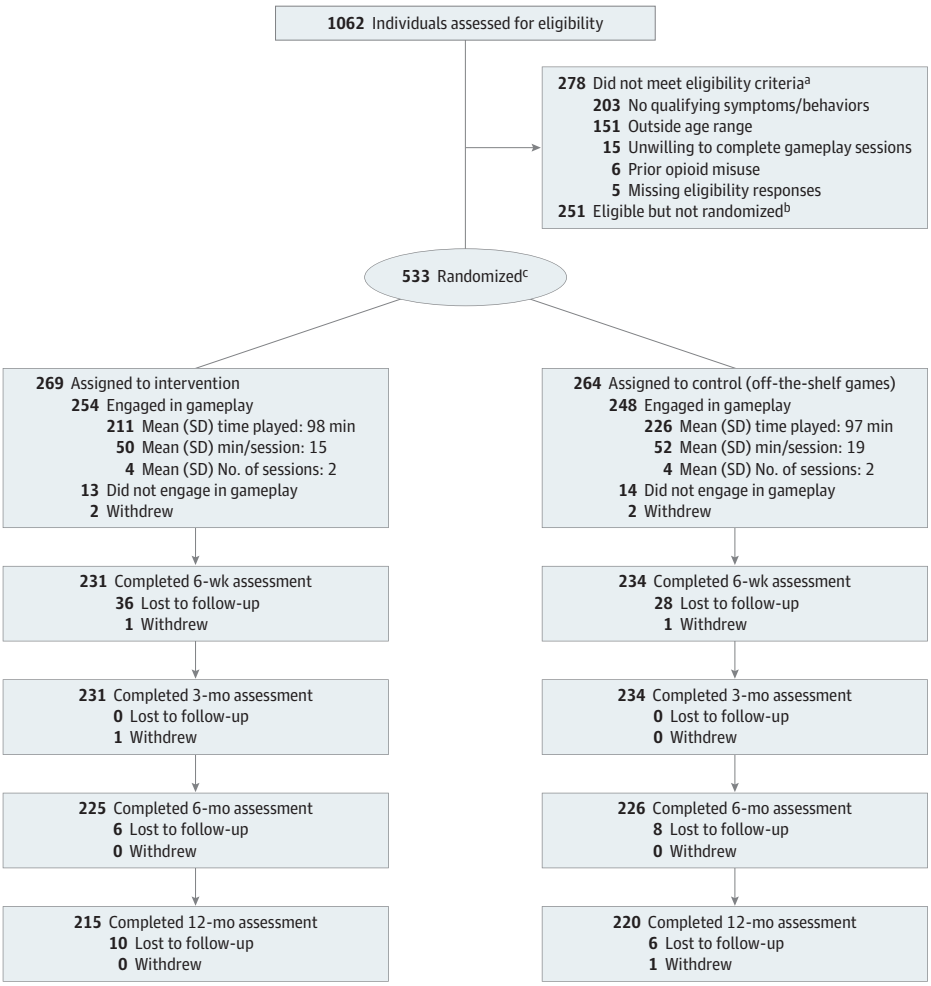
We conducted a parallel-group superiority RCT to evaluate the effects of a digital behavioral health game on mental health and psychosocial outcomes among adolescents. Participants were high school students recruited from 15 Connecticut SBHPs; they were enrolled from October 21, 2021, to February 27, 2024, and followed up as long as 12 months. Eligibility included 16 to 19 years of age, no prior opioid misuse, and reporting past 30-day use of alcohol, cannabis, nicotine, or other nonopioid substances or screening positive for depressive or anxiety symptoms (2-item Patient Health

Questionnaire or 2-item Generalized Anxiety Disorder Scale scores ≥1).[20] Additional criteria included willingness to complete 60-minute gameplay sessions during several weeks and the ability to provide written assent or informed consent (with parental consent for minors). Participants had access to usual school-based services. **Figure 1** shows participant flow. The trial was approved by Yale School of Medicine Institutional Review Board, and the Dartmouth Committee for the Protection of Human Subjects relied on Yale for continuing oversight under a formal Institutional Review Board authorization agreement. This study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guideline.[21] Complete protocol details have been published[18] and are provided in Supplement 1. Prespecified primary outcome findings (perceived risk of opioid misuse harm at 3 months) have been published, along with outcome-specific power calculations.[19] Depressive and anxiety symptoms were prespecified secondary outcomes not used to determine sample size.

Randomization and Procedures

Participants were randomized 1:1 to the digital game intervention or an active control using a REDCap-embedded scheme stratified by sex at birth (male or female) and grade level (9th-10th or 11th-12th). Randomization was conducted by a senior statistician after baseline assessment. Study staff accessed the randomization system only after participants completed baseline assessments, ensuring concealment of the allocation sequence. Assessments were administered at baseline, 6

Figure 1. Study Flow Diagram



[a] Reasons for ineligibility were not mutually exclusive.

[b] Reasons included not returning the enrollment packet, lack of time after school, transportation issues, and other family, work, or school commitments.

[c] One participant randomized to the control group was subsequently withdrawn due to missing parental consent form.

weeks (immediately after gameplay), and 3, 6, and 12 months. Analysts remained blinded to outcome data until after database lock.

Intervention Group

The intervention consisted of a theory-driven digital health game developed through iterative youth codesign and informed by social cognitive theory, theory of planned behavior, the health belief model, and prior game-based mental health interventions developed by the team, including empowerED, which targeted cognitive reappraisal and emotion self-regulation.[9,22-27] Across 6 interactive storylines, players navigate scenarios involving prescription opioid safety, resisting negative peer pressure, recognizing signs of emotional distress among peers, supporting friends affected by substance misuse, and seeking help or counseling. Six skill-based minigames target (1) risk assessment and decision-making, (2) critical evaluation of social media and/or online information, (3) cognitive distortions that lead to emotional distress, (4) refusal skills in resisting peer pressure, (5) knowledge acquisition through text-based interactions with peers, and (6) anticipation of future consequences based on present-day choices. These components were designed to strengthen coping, help-seeking attitudes, peer support, self-efficacy, and decision-making skills hypothesized to improve mental health outcomes. The intervention game was delivered on tablets (iPad; Apple Corporation) during 40- to 60-minute sessions held 1 to 2 times weekly in school, after class, or during designated free periods during a maximum study period of 6 weeks.[18,19]

Control Group

Active control participants played games from a menu of 9 commercially available games (eg, The Sims [Electronic Arts Inc], Papers Please [3909 LLC]). The games required equivalent time and attention but lacked outcome-related content.

Measures

Sociodemographic Characteristics

Sociodemographic data were collected via standardized self-report items defined by the investigator to describe the sample and examine heterogeneity of intervention effects. These included age, grade, sex, race and ethnicity, food insecurity, familial substance misuse, and peer norms. Racial categories included American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, and other (including write-in responses); ethnicity categories included Hispanic or Latinx.

Depressive Symptoms

Depressive symptoms were assessed using the 8-item Patient Health Questionnaire (PHQ-8). Items asked about past 2-week frequency of depressive symptoms, rated from 0 (not at all) to 3 (nearly every day) for a total score ranging from 0 to 24.[28] Scores of 5 to 9 indicated mild symptoms; 10 to 14, moderate symptoms; 15 to 19, moderately severe symptoms; and 20 to 24, severe symptoms. The PHQ-8 has demonstrated strong internal reliability and validity across adolescent samples.[29,30]

Anxiety Symptoms

Anxiety symptoms were measured with the 7-item Generalized Anxiety Disorder Scale (GAD-7), which assessed past 2-week frequency of anxiety symptoms and were rated on the same scale of 0 to 3 as described for the PHQ-8.[31] Total scores ranged from 0 to 21, with 5 to 9 indicating mild symptoms; 10 to 14, moderate symptoms; and 15 to 21, severe symptoms. GAD-7 has demonstrated strong reliability and construct validity among diverse adolescent samples.[29,32,33]

BAPS

Attitudes toward seeking psychological help were measured with the 18-item BAPS scale. Original response options were binarized (true or false). Items assessed willingness to seek or recommend

professional help, perceived benefits of counseling, and concerns about stigma. Seven items were reverse scored. Mean scores were calculated for a composite score ranging from 0 to 1, with higher scores indicating more favorable beliefs.[34] Internal consistency in this sample was acceptable (Cronbach α = 0.70).

Help-Seeking Intentions

Intentions to seek help were assessed with the General Help-Seeking Questionnaire (GHSQ), which asked respondents to rate how likely they would be to seek help from formal sources (mental health professionals, helplines, physicians, and religious leaders) and informal sources (intimate partners, friends, parents, and other relatives) if experiencing personal or emotional problems (A) or suicidal ideation (B). Responses were indicated on a 7-point Likert scale (ranging from extremely unlikely [1] to extremely likely [7]).[35,36] Mean ratings were calculated to yield a composite score, with higher scores indicating greater intention to seek help. Internal consistencies for both subscales were good (Cronbach α = 0.79-0.86).

Emotion Regulation

Difficulties in emotion regulation were assessed using a modified version of the State Difficulties in Emotion Regulation Scale (S-DERS). Participants responded based on their past-week feelings using a 5-point scale ranging from 1 (not at all) to 5 (completely). This version had 10 items across 3 S-DERS domains: impulse and control, awareness, and modulation.[37] Mean items were calculated such that higher scores indicated greater difficulty with emotion regulation. The scale demonstrated good internal consistency in this sample (Cronbach α = 0.80).

Statistical Analysis

Analyses were conducted in SAS, version 9.4 (PROC GLIMMIX package for modeling [SAS Institute Inc]) and R, version 4.5.1 (exploratory mediation package [R Project for Statistical Computing]). For continuous outcomes, linear mixed-effects models included a participant-level random intercept to account for repeated measures with empirical SEs for robust inference. Unadjusted models examined all 5 assessments (baseline through 12 months) as a function of intervention group, time, and group-by-time interaction. Adjusted models controlled for baseline outcome values, sex, and grade level to estimate postrandomization differences with greater precision. Moderation analyses tested for heterogeneity of intervention effects on depressive symptoms by sex, grade level, food insecurity, familial substance misuse, and peer substance use norms; all moderators were dichotomous variables and examined in exploratory post hoc 3-way interaction models.

Analyses followed the intention-to-treat principle using mixed models under a missing-at-random assumption, with sample sizes varying by time point. A 2-sided α = .05 was used to assess statistical significance. Mental health outcomes were prespecified as secondary end points in the trial registration, and mediation and moderation analyses were exploratory and hypothesis generating. Sample size was based on the overall trial design rather than powered specifically for these outcomes.[18,19]

Because psychosocial constructs (BAPS, GHSQ A and B, and S-DERS) were conceptualized as early-changing mechanisms preceding symptom change, we interpreted the adjusted group differences at the 6-week (post gameplay) assessment from models including group, time, and group-by-time. The 6-week contrast reflects the theoretically relevant window for proximal effects.

Since the intervention showed improvements in both depressive symptoms and BAPS, we conducted an exploratory post hoc mediation analysis to examine whether changes in help-seeking beliefs at 6 weeks were associated with depressive symptoms at subsequent follow-up assessments (3, 6, and 12 months). Linear regression models estimated the indirect effect, adjusting for baseline BAPS score, baseline PHQ-8 score, sex, and grade level; mediation effects were estimated with 2000 simulations (R mediation package). Mediation models used complete cases (424 at 3 months; 406 at 6 months; 393 at 12 months), with results unchanged in a sensitivity analysis using multiple

imputation (m = 50). Effect sizes (Cohen *d* values) were calculated by dividing the adjusted between-group mean difference estimated from the mixed-effects models at the relevant follow-up time point by the pooled baseline SD of the outcome.

Results

Table 1 shows baseline sample characteristics. A total of 532 adolescents (mean [SD] age, 16.6 [0.7] years) were analyzed after randomization to the intervention group (n = 269) or control group (n = 263). At baseline, 284 adolescents (53.4%) identified as male and 248 (46.6%) as female. In terms of race, 22 adolescents (4.1%) identified as American Indian or Alaska Native, 44 (8.3%) as Asian, 241 (45.3%) as Black or African American, 7 (1.3%) as Native Hawaiian or Other Pacific Islander, 179 (33.6%) as White, and 101 (19.0%) as other race; in terms of ethnicity, 202 (38.0%) identified as Hispanic or Latinx. Baseline mean (SD) scores were 6.91 (5.28) for the PHQ-8 and 5.29 (4.62) for the GAD-7, indicating mild symptom severity. Baseline characteristics were similar across study groups.

Table 1. Participant Characteristics at Baseline

Characteristics	Participant group, No. (%)		
	Overall (N = 532)	Intervention (n = 269)	Control (n = 263)
Age, mean (SD), y	16.6 (0.7)	16.6 (0.7)	16.6 (0.8)
Sex			
Female	248 (46.6)	127 (47.2)	121 (46.0)
Male	284 (53.4)	142 (52.8)	142 (54.0)
Race[a]			
American Indian or Alaska Native	22 (4.1)	14 (5.2)	8 (3.0)
Asian	44 (8.3)	19 (7.1)	25 (9.5)
Black or African American	241 (45.3)	128 (47.6)	113 (43.0)
Native Hawaiian or Other Pacific Islander	7 (1.3)	2 (0.7)	5 (1.9)
White	179 (33.6)	86 (32.0)	93 (35.4)
Other[b]	101 (19.0)	50 (18.6)	51 (19.4)
Hispanic or Latinx ethnicity	202 (38.0)	100 (37.2)	102 (38.8)
Grade level			
9-10	87 (16.4)	44 (16.4)	43 (16.3)
11-12	445 (83.6)	225 (83.6)	220 (83.7)
Food insecurity			
None	354 (66.5)	185 (68.8)	169 (64.3)
Any	178 (33.5)	84 (31.2)	94 (35.7)
Familial substance misuse[c]			
None	337 (70.1)	173 (70.9)	164 (69.2)
Any	144 (29.9)	71 (29.1)	73 (30.8)
Peer substance use norms			
Lower	153 (28.8)	76 (28.3)	77 (29.3)
Higher (≥1 peer uses regularly)	379 (71.2)	193 (71.7)	186 (70.7)
Mental health, mean (SD)			
PHQ-8 score[d]	6.91 (5.28)	6.87 (5.38)	6.92 (5.19)
GAD-7 score[e]	5.29 (4.62)	5.43 (4.91)	5.11 (4.29)
Psychosocial outcomes, mean (SD)			
BAPS score[f]	0.71 (0.18)	0.72 (0.18)	0.71 (0.18)
GHSQ A score[g]	3.68 (1.09)	3.67 (1.07)	3.68 (1.12)
GHSQ B score[g]	3.82 (1.52)	3.88 (1.56)	3.75 (1.49)
S-DERS score[h]	2.16 (0.66)	2.16 (0.69)	2.17 (0.63)

Abbreviations: BAPS, Beliefs About Psychological Services; GAD-7, 7-item Generalized Anxiety Disorder; GHSQ-A, General Help-Seeking Questionnaire for personal/emotional problems; GHSQ-B, GHSQ for suicidal ideation; PHQ-8, 8-item Patient Health Questionnaire; S-DERS, State Difficulties in Emotion Regulation Scale.

[a] Identifed using "select all that apply"; percentages sum to greater than 100%.

[b] Includes write-in response.

[c] Percentages were calculated among participants who reported familial substance misuse status; 51 participants selected prefer not to say.

[d] Scores range from 0 to 24, with higher scores indicating greater depressive symptom severity;

[e] Scores range from 0 to 21, with higher scores indicating greater anxiety symptom severity.

[f] Scores range from 0 to 1, with higher scores indicating more favorable beliefs.

[g] Scores range from 1 to 7, with higher scores indicating greater intention to seek help.

[h] Scores range from 1 to 5, with higher scores indicating greater difficulty with emotion regulation.

Outcomes

Table 2 shows model results for mental health outcomes. At 12 months, adjusted mean PHQ-8 scores were 5.30 (95% CI, 4.74-5.86) in the intervention group and 6.42 (95% CI, 5.86-6.98) in the control group. For depressive symptoms, the group-by-time interaction was significant ($F_{3,1308}$ = 2.93; P = .03), indicating differential depressive symptom trajectories between intervention and control participants (**Figure 2**). In adjusted models, intervention participants had PHQ-8 scores that were 1.12 points lower than those of control participants at 12 months (95% CI, −1.85 to −0.38 points; P = .002; Cohen d = 0.21). Moderation analyses showed no differential intervention effects across subgroups (sex, grade level, food insecurity, peer norms, or familial substance misuse).

For anxiety symptoms, the group-by-time interaction was not significant ($F_{3,1308}$ = 1.69; P = .17). No between-group differences in anxiety symptoms were detected at follow-up assessments.

For BAPS, intervention participants reported higher scores at 6 weeks (adjusted difference, 0.03 [95% CI, 0.01-0.05]). The group-by-time interaction was not significant. Consistent with our conceptualization of BAPS as a proximal target, the adjusted between-group difference at 6 weeks was significant ($F_{1,1257}$ = 8.59; P = .003), with intervention participants reporting more positive BAPS than control participants immediately post gameplay. Mean differences remained similar at subsequent assessments, suggesting that early improvements were sustained over time (**Table 3**). There were no significant effects on help-seeking intentions (GHSQ) or emotion regulation (S-DERS).

Consistent with the primary outcome report of this trial, 2 mild adverse events were documented during the study (1 at baseline and 1 at 6 weeks), both involving brief discomfort during or after gameplay and judged as possibly related to the intervention. No serious or unexpected harms occurred.[19]

Table 2. Association of Intervention With Mental Health Symptom Trajectories During 12-Month Follow-Up[a]

Outcome	Group-by-time interaction		Adjusted mean difference at 12 mo [intervention − control] (95% CI)[b]	Effect size, Cohen d[c]
	$F_{3,\ 1308}$ value	P value		
PHQ-8	2.93	.03	−1.12 (−1.85 to −0.38)	0.21
GAD-7	1.69	.17	−0.60 (−1.33 to 0.14)	0.13

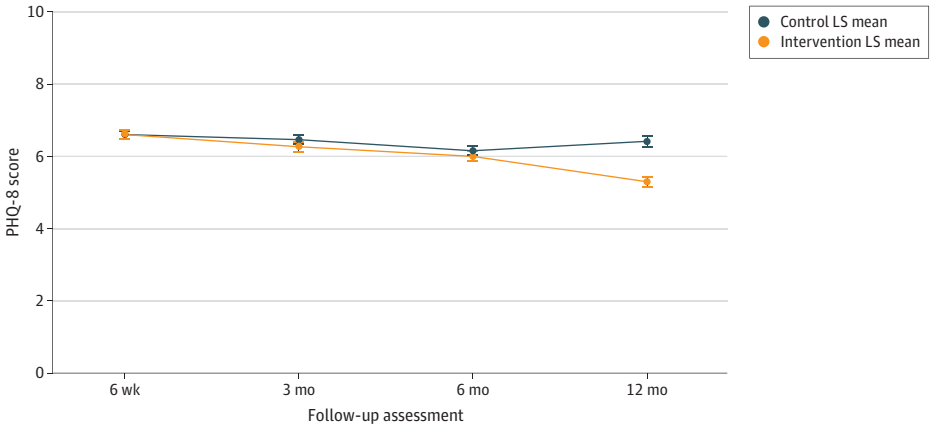
Abbreviations: GAD-7, 7-item Generalized Anxiety Disorder; PHQ-8, 8-item Patient Health Questionnaire.

[a] Models adjusted for baseline value of the outcome, sex, and grade level.

[b] Calculated as intervention minus control.

[c] Calculated using the pooled baseline SD for each measure.

Figure 2. Adjusted 8-Item Patient Health Questionnaire (PHQ-8) Symptom Trajectories by Group During 12 Months of Follow-up



Values represent least-squares (LS) means from mixed-effects models adjusted for baseline PHQ-8 score, sex, and grade level. Error bars reflect model-based SEs. Lower PHQ-8 scores reflect lower severity of depressive symptoms.

Exploratory Mediation

Intervention group assignment was associated with improved BAPS at 6 weeks. At 6 months, a small indirect effect was observed (average causal mediation effect = −0.13 [95% CI, −0.30 to −0.01; *P* = .02]), indicating that early improvements in BAPS partially mediated the association of the intervention with subsequent reductions in depressive symptoms. No mediation effects were detected at 3 or 12 months.

Discussion

In this prespecified secondary analysis of an RCT conducted in SBHPs, a codesigned digital behavioral health game yielded modest but sustained reductions in depressive symptoms during 12 months of follow-up when compared with an active control. Intervention participants also reported more positive BAPS immediately post gameplay, which suggests that the intervention may reduce attitudinal barriers to help-seeking in the short term, and exploratory mediation analyses suggested that these early attitudinal shifts may have contributed to subsequent reductions in depressive symptoms. No associations were observed for anxiety symptoms or remaining psychosocial outcomes. Intervention associations did not differ by sex, grade level, food insecurity, peer norms, or familial substance misuse.[38-41]

Our findings add to growing evidence on digital games and interactive media in promoting adolescent mental health.[8,13,14,24,42-44] Gamification has strong potential to increase engagement and mitigate stigma for youth.[5,14,45] However, many digital interventions are treatment focused for selective and indicated populations, demonstrate short-term effects, or use passive control groups that leave open questions about nonspecific effects of novelty, attention, or technology use.[13,14] By using an active control matched on gameplay time and interaction demands, this trial provides a stringent test of content-specific intervention effects.[18] The observed reduction in depressive symptoms suggests that embedding skill-building within interactive narratives may support mental health in school-based settings. Future research should identify which features are most influential and how to transfer them to other digital interventions.

The improvement in BAPS offers insight into how such effects may occur. Although mediation analysis was exploratory and post hoc, patterns suggest the possibility that early shifts in beliefs contributed to short-term reductions in depressive symptoms. This aligns with theoretical models that informed the development of the intervention, such as the health belief model, social cognitive theory, and theory of planned behavior, which emphasize that shifts in beliefs, attitudes, and perceived barriers, benefits, and capabilities are proximal determinants of help-seeking intentions and coping behaviors that can, in turn, influence emotional outcomes.[9,25-27] Notably, the indirect effect did not persist to 12 months, suggesting that changes in BAPS alone are unlikely to fully explain

Table 3. Between-Group Differences at 6 Weeks From Mixed-Effects Models[a]

Outcome	Group effect		Adjusted mean difference at 6 wk (95% CI)[b]	Effect size, Cohen *d*[c]
	F value (*df*)	*P* value		
BAPS	8.59 (1, 1257)	.003	0.03 (0.01 to 0.05)	0.17
GHSQ A	3.06 (1, 1259)	.08	0.16 (−0.04 to 0.36)	0.15
GHSQ B	1.08 (1, 1258)	.30	0.13 (−0.09 to 0.36)	0.09
S-DERS	1.35 (1, 1281)	.25	−0.07 (−0.16 to 0.03)	0.10

Abbreviations: BAPS, Beliefs About Psychological Services; GHSQ A, General Help-Seeking Questionnaire for personal/emotional problems; GHSQ B, GHSQ for suicidal ideation; S-DERS, State Difficulties in Emotion Regulation Scale.

[a] Models include group, time, and group-by-time interactions; the group test reflects the adjusted between-group difference at the reference time point (6 weeks, immediately post-gameplay). Models adjust for baseline outcome value, sex, and grade level.

[b] Calculated as intervention minus control.

[c] Calculated using the pooled baseline SD for each measure.

depressive symptom reductions and that additional mechanisms may be involved. Future studies should explicitly test these mechanisms.

Effect sizes for depressive symptom change were small (Cohen *d* = 0.21) but typical of universal and selective prevention programs targeting broad populations rather than diagnosed clinical conditions.[4,46] Although the 1.12-point between-group difference may not represent an individually meaningful change, this shift could translate to considerable public health benefit when delivered at scale. However, the divergence between intervention and control group trajectories at 12 months—but not sooner—warrants discussion. The delayed reduction in depressive symptoms in the intervention group may be indicative of a sleeper effect, where youths absorb and retain the game's coping and cognitive-reframing skills but initially discount the intervention because it feels like "just a game." As early resistance fades, skills may become salient and actionable outside the game, leading to mental health benefits that emerge later.[47,48]

The absence of detectable effects on anxiety symptoms is not entirely unsurprising, given the evidence base to date. Digital mental health interventions more commonly improve symptoms of depression than anxiety.[14,49,50] In our trial, the absence of effects on anxiety symptoms may reflect differences in processes targeted by the intervention. The intervention game emphasized emotion awareness, social support, and beliefs about the value and acceptability of seeking help, processes closely tied to depressive symptoms like withdrawal and reduced perceived agency.[51,52] In contrast, anxiety is often maintained by avoidance and physiologic arousal and typically responds to interventions incorporating exposure, worry management, or relaxation-based skills,[53] which were not core components of the intervention. Thus, the differential effect pattern is theory consistent and suggests that future adaptations may need anxiety-focused content for broader internalizing symptom impact. The absence of effects on other psychosocial outcomes may reflect limited intervention impact on those domains or insufficient power to detect small differences.

Strengths and Limitations

This study has noteworthy strengths. Randomization supports causal inference of intervention effects. The trial incorporated an active control, longitudinal follow-up to 12 months, and rigorous mixed-effects modeling under an intention-to-treat framework. The sample was large, racially and ethnically diverse, and recruited from SBHPs that primarily serve adolescents who may face barriers to traditional mental health care. In total, 45.3% of participants identified as Black or African American and 38.0% as Hispanic or Latinx—groups that, according to the 2023 Youth Risk Behavior Survey, report some of the highest levels of sadness and hopelessness, reinforcing the importance of scalable prevention to address persistent mental health inequities.[54] The intervention was codesigned with and well-received by youths[19] and delivered in SBHPs, which may reduce access barriers and support broader implementation. Finally, the intervention was intended for prevention, which is greatly needed in this space.[8]

Limitations of this study should also be noted. Variables were self-reported and may be influenced by response bias. Effects on secondary outcomes and mediation pathways were exploratory, and findings should be interpreted in the context of multiple secondary and exploratory outcomes evaluated. Replication in future preregistered studies is needed. The intervention's gameplay dose was standardized, but engagement quality, narrative resonance, and expectancy effects were not measured. Additionally, while intervention effects did not differ by baseline symptom severity or other examined subgroups, the trial was not powered to detect small subgroup differences, and future studies should examine them explicitly.

Conclusions

In this secondary analysis of an RCT, the intervention was associated with lower depressive symptom scores and short-term improvements in BAPS among a diverse adolescent population. These findings support the promise of serious digital games as scalable, nonclinical mental health

promotion strategies that may complement existing services in school- and community-based settings. Future work should refine mechanisms of action, examine implementation and sustainability within schools and other youth-oriented settings, and evaluate strategies to enhance and maintain benefits over time. This trial provides preliminary evidence that a codesigned digital game delivered in schools may support aspects of adolescent mental health.

ARTICLE INFORMATION

Accepted for Publication: June 24, 2026.

Published: August 17, 2026. doi:10.1001/jamanetworkopen.2026.29173

Corresponding Author: Caroline M. Barry, PhD, MPH, 46 Centerra Pkwy, Lebanon, NH 03766 (caroline.m.barry@dartmouth.edu).

Author Affiliations: play2PREVENT Lab, Geisel School of Medicine, Dartmouth College, Hanover, New Hampshire (Barry, Boomer, Haile, Fiellin); Center for Technology and Behavioral Health, Geisel School of Medicine at Dartmouth, Hanover, New Hampshire (Barry, Boomer, Haile, Xie, Fiellin); Department of Biomedical Data Science, Geisel School of Medicine at Dartmouth, Hanover, New Hampshire (Barry, Xie, Fiellin).

Author Contributions: Drs Barry and Xie had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Barry, Boomer, Haile, Fiellin.

Acquisition, analysis, or interpretation of data: Barry, Xie, Fiellin.

Drafting of the manuscript: Barry, Fiellin.

Critical review of the manuscript for important intellectual content: All authors.

Statistical analysis: Barry, Xie.

Obtained funding: Fiellin.

Administrative, technical, or material support: Barry, Boomer, Haile, Fiellin.

Supervision: Boomer, Fiellin.

Conflict of Interest Disclosures: Ms Boomer reported receiving royalties from Yale University under a licensing agreement with Playbl, a mission-driven digital health company that develops and disseminates evidence-based, game-based interventions to promote adolescent behavioral health and prevent substance misuse. Dr Fiellin reported receiving grant support from Yale University and Dartmouth College during the conduct of the study and being a founder and equity holder in Playbl outside the submitted work; Playbl is a spin-out of the play2PREVENT Lab that markets and distributes videogame interventions developed and tested by the Lab. This relationship is extensively managed by Dr Fiellin and Yale University and Dr Fiellin and Dartmouth College. This management, which is closely followed, includes Dr Fiellin (1) not being involved in any interactions with study participants including the selection, enrollment, or consenting of participants, or determination of participant eligibility and (2) not participating in data collection and maintaining an independent data analysis team. No other disclosures were reported.

Funding/Support: Research reported in this publication was supported by award 4UH3DA050251-03 from the National Institute on Drug Abuse (NIDA) as part of the HEAL Initiative and training grant T32DA037202 from the NIDA.

Role of the Funder/Sponsor: The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Data Sharing Statement: See Supplement 2.

Additional Contributions: We thank the youths who participated in this study, without whom this work would not have been possible. We also thank our partner schools and school-based health programs for their collaboration and support. We acknowledge the study staff for their contributions to participant recruitment, data collection, and study implementation. We also thank the game design and development partners, Ben Sawyer, compensated as a consultant, and the team at Schell Games LLC, who were deeply involved in the creation of PlaySmart.

REFERENCES

1. Xiang AH, Martinez MP, Chow T, et al. Depression and anxiety among US children and young adults. *JAMA Netw Open*. 2024;7(10):e2436906. doi:10.1001/jamanetworkopen.2024.36906

2. Percentage of teens aged 12-17 years with symptoms of anxiety during the past 2 weeks, United States, July 2021-December 2023. National Health Interview Survey-Teen. National Center for Health Statistics. 2025. Accessed November 21, 2025. https://wwwn.cdc.gov/NHISDataQueryTool/NHIS_TEEN/index.html

3. Key substance use and mental health indicators in the United States: results from the 2024 National Survey on Drug Use and Health. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration. 2025. Accessed December 15, 2025. https://www.samhsa.gov/data/data-we-collect/nsduh-national-survey-drug-use-and-health/national-releases

4. Cohen KA, Ito S, Ahuvia IL, et al. Brief school-based interventions targeting student mental health or well-being: a systematic review and meta-analysis. *Clin Child Fam Psychol Rev*. 2024;27(3):732-806. doi:10.1007/s10567-024-00487-2

5. Fleming T, Poppelaars M, Thabrew H. The role of gamification in digital mental health. *World Psychiatry*. 2023;22(1):46-47. doi:10.1002/wps.21041

6. Singh V, Kumar A, Gupta S. Mental health prevention and promotion—a narrative review. *Front Psychiatry*. 2022;13:898009. doi:10.3389/fpsyt.2022.898009

7. Abt CC. *Serious Games*. Viking Press; 1970. Accessed December 16, 2025. http://archive.org/details/seriousgames0000abtc

8. Baka E, Tan YR, Wong BLH, Xing Z, Yap P. A scoping review of digital interventions for the promotion of mental health and prevention of mental health conditions for young people. *Oxf Open Digit Health*. 2025;3:oqaf005. doi:10.1093/oodh/oqaf005

9. Aneni K, Fernandes CF, Hoerner LA, Szapary C, Pendergrass Boomer TM, Fiellin LE. A video game intervention to prevent opioid misuse among older adolescents: development and preimplementation study. *JMIR Serious Games*. 2023;11:e46912. doi:10.2196/46912

10. Hieftje KD, Fernandes CF, Lin IH, Fiellin LE. Effectiveness of a web-based tobacco product use prevention videogame intervention on young adolescents' beliefs and knowledge. *Subst Abus*. 2021;42(1):47-53. doi:10.1080/08897077.2019.1691128

11. Fiellin LE, Hieftje KD, Pendergrass TM, et al. Video game intervention for sexual risk reduction in minority adolescents: randomized controlled trial. *J Med Internet Res*. 2017;19(9):e314. doi:10.2196/jmir.8148

12. Boomer TP, Larkin K, Duncan LR, Fernandes CF, Fiellin LE. A serious video game targeting HIV testing and counseling: a randomized controlled trial. *J Adolesc Health*. 2024;74(2):252-259. doi:10.1016/j.jadohealth.2023.08.016

13. Aschentrup L, Steimer PA, Dadaczynski K, Mc Call T, Fischer F, Wrona KJ. Effectiveness of gamified digital interventions in mental health prevention and health promotion among adults: a scoping review. *BMC Public Health*. 2024;24(1):69. doi:10.1186/s12889-023-17517-3

14. Bryant BR, Sisk MR, McGuire JF. Efficacy of gamified digital mental health interventions for pediatric mental health conditions: a systematic review and meta-analysis. *JAMA Pediatr*. 2024;178(11):1136-1146. doi:10.1001/jamapediatrics.2024.3139

15. Ridenour TA, Saavedra LM, Fernandes CF, Cance JD, Graham PW, Oudekerk BA. Introduction to helping to end addiction long-term prevention cooperative: overview and strategies. *Prev Sci*. 2023;24(suppl 1):1-7. doi:10.1007/s11121-023-01503-7

16. Ridenour TA, Cruden G, Yang Y, et al. Methodological strategies for prospective harmonization of studies: application to 10 distinct outcomes studies of preventive interventions targeting opioid misuse. *Prev Sci*. 2023;24(1)(suppl 1):16-29. doi:10.1007/s11121-022-01412-1

17. Yule AM, Fernandes CF, Stormshak EA, et al. Multidisciplinary strategies for preventing opioid misuse and escalation by targeting mental health symptoms and conditions. *Prev Sci*. 2023;24(suppl 1):77-87. doi:10.1007/s11121-023-01556-8

18. Pendergrass Boomer TM, Hoerner LA, Fernandes CSF, et al. A digital health game to prevent opioid misuse and promote mental health in adolescents in school-based health settings: protocol for the PlaySmart game randomized controlled trial. *PLOS One*. 2023;18(9):e0291298. doi:10.1371/journal.pone.0291298

19. Boomer T, Hoerner L, Larkin K, Maciejewski K, Kyriakides TC, Fiellin LE. A videogame for perceived risk of harm from opioid misuse in adolescents: a randomized controlled trial. *Nat Health*. 2026;1(1):78-89. doi:10.1038/s44360-025-00010-z

20. Staples LG, Dear BF, Gandy M, et al. Psychometric properties and clinical utility of brief measures of depression, anxiety, and general distress: the PHQ-2, GAD-2, and K-6. *Gen Hosp Psychiatry*. 2019;56:13-18. doi:10.1016/j.genhosppsych.2018.11.003

21. Hopewell S, Chan A, Collins GS, et al. CONSORT 2025 Statement: updated guideline for reporting randomized trials. *JAMA*. 2025;333(22):1998–2005. doi:10.1001/jama.2025.4347

22. Hieftje K, Duncan LR, Fiellin LE. Novel methods to collect meaningful data from adolescents for the development of health interventions. *Health Promot Pract*. 2014;15(5):714-722. doi:10.1177/1524839914521211

23. Duncan LR, Hieftje KD, Culyba S, Fiellin LE. Game playbooks: tools to guide multidisciplinary teams in developing videogame-based behavior change interventions. *Transl Behav Med*. 2014;4(1):108-116. doi:10.1007/s13142-013-0246-8

24. Fernandes CF, Deng Y, Tran AH, et al. A pilot randomized controlled trial to evaluate a cognitive behavioral videogame intervention: empowerED. *Games Health J*. 2023;12(1):42-52. doi:10.1089/g4h.2021.0118

25. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. *Health Educ Q*. 1988;15(2):175-183. doi:10.1177/109019818801500203

26. Bandura A. Health promotion by social cognitive means. *Health Educ Behav*. 2004;31(2):143-164. doi:10.1177/1090198104263660

27. Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process*. 1991;50(2):179-211. doi:10.1016/0749-5978(91)90020-T

28. Kroenke K, Strine TW, Spitzer RL, Williams JBW, Berry JT, Mokdad AH. The PHQ-8 as a measure of current depression in the general population. *J Affect Disord*. 2009;114(1-3):163-173. doi:10.1016/j.jad.2008.06.026

29. Vilela-Estrada AL, Villarreal-Zegarra D, Toyama M, et al. Psychometric properties of the Patient Health Questionnaire-8 and General Anxiety Disorder-7 in adolescents and young adults from three Latin American cities: internal structure, invariance, internal consistency and divergent validity. *J Affect Disord*. 2025;378:138-146. doi:10.1016/j.jad.2025.02.088

30. Arias de la Torre J, Vilagut G, Ronaldson A, et al. Reliability and cross-country equivalence of the 8-item version of the Patient Health Questionnaire (PHQ-8) for the assessment of depression: results from 27 countries in Europe. *Lancet Reg Health Eur*. 2023;31:100659. doi:10.1016/j.lanepe.2023.100659

31. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med*. 2006;166(10):1092-1097. doi:10.1001/archinte.166.10.1092

32. Pérez-Pedrogo C, Sánchez-Cardona I, Castro-Díaz B, López-Torres S. Psychometric properties of the Generalized Anxiety Disorder 7-item scale in adolescents: an effective screening tool for school and community settings. *P R Health Sci J*. 2022;41(4):226-232.

33. Mossman SA, Luft MJ, Schroeder HK, et al. The Generalized Anxiety Disorder 7-item scale in adolescents with generalized anxiety disorder: signal detection and validation. *Ann Clin Psychiatry*. 2017;29(4):227-234A. doi:10.1177/104012371702900404

34. Ægisdóttir S, Gerstein LH. Beliefs About Psychological Services (BAPS): development and psychometric properties. *Couns Psychol Q*. 2009;22(2):197-219. doi:10.1080/09515070903157347

35. Rickwood D, Deane FP, Wilson CJ, Ciarrochi J. Young people's help-seeking for mental health problems. *Aust eJ Adv Mental Health*. 2005;4(3):218-251. doi:10.5172/jamh.4.3.218

36. Wilson CJ, Deane FP, Ciarrochi J, Rickwood D. Measuring help-seeking intentions: properties of the General Help-Seeking Questionnaire. *Can J Counsell*. 2005;39(1):15-28.

37. Lavender JM, Tull MT, DiLillo D, Messman-Moore T, Gratz KL. Development and validation of a state-based measure of emotion dysregulation. *Assessment*. 2017;24(2):197-209. doi:10.1177/1073191115601218

38. Nagata JM, Palar K, Gooding HC, et al. Food insecurity is associated with poorer mental health and sleep outcomes in young adults. *J Adolesc Health*. 2019;65(6):805-811. doi:10.1016/j.jadohealth.2019.08.010

39. Reiss F. Socioeconomic inequalities and mental health problems in children and adolescents: a systematic review. *Soc Sci Med*. 2013;90:24-31. doi:10.1016/j.socscimed.2013.04.026

40. Hanson RF, Self-Brown S, Fricker-Elhai A, Kilpatrick DG, Saunders BE, Resnick H. Relations among parental substance use, violence exposure and mental health: the National Survey of Adolescents. *Addict Behav*. 2006;31(11):1988-2001. doi:10.1016/j.addbeh.2006.01.012

41. Dooley B, Fitzgerald A, Giollabhui NM. The risk and protective factors associated with depression and anxiety in a national sample of Irish adolescents. *Ir J Psychol Med*. 2015;32(1):93-105. doi:10.1017/ipm.2014.83

42. Merry SN, Stasiak K, Shepherd M, Frampton C, Fleming T, Lucassen MFG. The effectiveness of SPARX, a computerised self help intervention for adolescents seeking help for depression: randomised controlled non-inferiority trial. *BMJ*. 2012;344:e2598. doi:10.1136/bmj.e2598

43. Martinez K, Menéndez-Menéndez MI, Bustillo A. Awareness, prevention, detection, and therapy applications for depression and anxiety in serious games for children and adolescents: systematic review. *JMIR Serious Games*. 2021;9(4):e30482. doi:10.2196/30482

44. Choi E, Yoon EH, Park MH. Game-based digital therapeutics for children and adolescents: Their therapeutic effects on mental health problems, the sustainability of the therapeutic effects and the transfer of cognitive functions. *Front Psychiatry*. 2022;13:986687. doi:10.3389/fpsyt.2022.986687

45. Fleming T, Sutcliffe K, Lucassen M, Pine R, Donkin L. Serious games and gamification in clinical psychology. November 2, 2020. Accessed November 21, 2025. https://oro.open.ac.uk/75123/

46. Noh D, Kim H. Effectiveness of online interventions for the universal and selective prevention of mental health problems among adolescents: a systematic review and meta-analysis. *Prev Sci*. 2023;24(2):353-364. doi:10.1007/s11121-022-01443-8

47. Bell EC, Marcus DK, Goodlad JK. Are the parts as good as the whole? a meta-analysis of component treatment studies. *J Consult Clin Psychol*. 2013;81(4):722-736. doi:10.1037/a0033004

48. Kumkale GT, Albarracín D. The sleeper effect in persuasion: a meta-analytic review. *Psychol Bull*. 2004;130(1):143-172. doi:10.1037/0033-2909.130.1.143

49. Abd-Alrazaq A, Al-Jafar E, Alajlani M, et al. The effectiveness of serious games for alleviating depression: systematic review and meta-analysis. *JMIR Serious Games*. 2022;10(1):e32331. doi:10.2196/32331

50. Abd-Alrazaq A, Alajlani M, Alhuwail D, et al. The effectiveness of serious games in alleviating anxiety: systematic review and meta-analysis. *JMIR Serious Games*. 2022;10(1):e29137. doi:10.2196/29137

51. Walter HJ, Abright AR, Bukstein OG, et al. Clinical practice guideline for the assessment and treatment of children and adolescents with major and persistent depressive disorders. *J Am Acad Child Adolesc Psychiatry*. 2023;62(5):479-502. doi:10.1016/j.jaac.2022.10.001

52. Abramson LY, Seligman ME, Teasdale JD. Learned helplessness in humans: critique and reformulation. *J Abnorm Psychol*. 1978;87(1):49-74. doi:10.1037/0021-843X.87.1.49

53. Walter HJ, Bukstein OG, Abright AR, et al. Clinical practice guideline for the assessment and treatment of children and adolescents with anxiety disorders. *J Am Acad Child Adolesc Psychiatry*. 2020;59(10):1107-1124. doi:10.1016/j.jaac.2020.05.005

54. Centers for Disease Control and Prevention (CDC). 1991-2023 High School Youth Risk Behavior Survey Data. Accessed November 21, 2025. https://yrbs-explorer.services.cdc.gov/

SUPPLEMENT 1.
Trial Protocol

SUPPLEMENT 2.
Data Sharing Statement