JAMA | Original Investigation

A Vaping Cessation Text Message Program for Adolescent E-Cigarette Users
A Randomized Clinical Trial

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IMPORTANCE E-cigarettes are the most commonly used tobacco product among adolescents. Despite known harms of nicotine exposure among teens, there are no empirically tested vaping cessation interventions.

OBJECTIVE To compare the effectiveness of a text message program for nicotine vaping cessation among adolescents with assessment-only control.

DESIGN, SETTING, AND PARTICIPANTS A parallel, 2-group, double-blind, individually randomized clinical trial with follow-ups at 1 and 7 months after randomization was conducted from October 1, 2021, to October 18, 2023. Participants were recruited via social media ads; the intervention was delivered via text message; and assessments were completed online or by telephone. Eligible individuals were US residents aged 13 to 17 years who reported past 30-day e-cigarette use, were interested in quitting within 30 days, and owned a mobile phone with an active text message plan. To optimize study retention, all participants received monthly assessments via text message about e-cigarette use.

INTERVENTIONS Assessment-only controls (n = 744) received only study retention text messages. Intervention participants (n = 759) also received an automated, interactive text message program for vaping cessation that delivers cognitive and behavioral coping skills training and social support.

MAIN OUTCOMES AND MEASURES The primary outcome was self-reported 30-day point-prevalence abstinence from vaping at 7 months analyzed as intention-to-treat, with missingness coded as vaping.

RESULTS Among n = 1503 adolescents randomized, average age was 16.4 (SD, 0.8) years. The sample was 50.6% female, 42.1% male, and 7.4% nonbinary/other; 10.2% Black/African American, 62.6% White, 18.5% multiracial, and 8.7% another race; 16.2% Hispanic; 42.5% sexual minority; and 76.2% vaped within 30 minutes of waking. The 7-month follow-up rate was 70.8%. Point-prevalence abstinence rates were 37.8% (95% CI, 34.4%-41.3%) among intervention participants and 28.0% (95% CI, 24.9%-31.3%) among control participants (relative risk, 1.35 [95% CI, 1.17-1.57]; $P < .001$). No baseline variables moderated the treatment-outcome relationship. There was no evidence that adolescents who quit vaping transitioned to combustible tobacco products.

CONCLUSIONS AND RELEVANCE A tailored, interactive text message intervention increased self-reported vaping cessation rates among adolescents recruited via social media channels.

TRIAL REGISTRATION ClinicalTrials.gov Identifier: NCT04919590

Visual Abstract

Editorial pages 711 and 709

Multimedia

Supplemental content

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JAMA. 2024;332(9):713-721. doi:10.1001/jama.2024.11057
Published online August 7, 2024.

E-cigarettes have been the most commonly used tobacco product among adolescents in the United States for nearly a decade.[1] In 2023, more than 2.1 million adolescents reported current e-cigarette use (10% of high school students, 4.6% of middle school students).[2] There is no safe level of e-cigarette use for adolescents.[3] Nicotine use during adolescence affects learning, memory, and attention[4] and increases risk for mental health problems and addiction to other drugs later in life.[3] E-cigarettes also expose adolescents to numerous toxic substances[5] and health risks, such as exacerbations of asthma, bronchitis, and respiratory tract irritation.[6]

Development of vaping cessation interventions is a public health imperative. Indicators of nicotine addiction among adolescent e-cigarette users have increased substantially in recent years,[7] and more than one-third vape frequently (≥20 d/mo).[2] Young e-cigarette users want to quit,[8] largely for health and social reasons,[9] and a majority try to quit each year, mostly unassisted or using unproven methods.[10] Although several vaping cessation programs are available[11] with evaluation efforts underway,[12] there are no published randomized trials of interventions to stop e-cigarette use among adolescents.[12]

To fill this gap, a comparative effectiveness randomized clinical trial (RCT) of a vaping cessation intervention for adolescents was conducted. Delivered via text message, the intervention was proven effective among young adults in the only vaping cessation trial published to date.[13] The present study tested the hypothesis that adolescents in the intervention group would be more likely to be abstinent at 7 months than participants in an assessment-only control group.

Key Points

Question Is a tailored, interactive text message program for vaping cessation effective in promoting abstinence from e-cigarettes among adolescents?

Findings A 2-group randomized clinical trial was conducted with 1503 adolescent e-cigarette users, with 70.8% retention at 7 months. In intention-to-treat analysis, with missingness coded as vaping, abstinence rates were 37.8% among participants assigned to the text message intervention and 28.0% among participants assigned to assessment-only control, a statistically significant difference. No baseline characteristics moderated the treatment-outcome relationship, including nicotine dependence.

Meaning A tailored, interactive text message program increased self-reported vaping cessation rates among adolescents recruited via social media channels.

Methods

Trial Design

This double-blind individually randomized RCT compared a tailored, interactive text message intervention ("intervention") to assessment-only control among adolescents reporting past 30-day e-cigarette use. The study was registered on ClinicalTrials.gov (NCT04919590) (Supplement 1). Results are reported according to the CONSORT (Consolidated Standards of Reporting Trials) guideline. A data and safety monitoring board was used.

Participants

Eligibility criteria were age (13-17 years), current (past 30-day) e-cigarette use, interest in quitting vaping within 30 days, mobile phone ownership with text message plan, and US residence. The study was conducted by Truth Initiative; the protocol was approved by the Advarra institutional review board (Pro00056204). A waiver of parental consent was approved by the review board since adolescents may hide e-cigarette use from parents.[14,15] Study information was written at a fifth-grade reading level; individuals were required to correctly answer 7 questions about the study indicating decisional capacity to enroll. Individuals who did not pass decisional capacity were directed to a free quit vaping program.

A waitlist control group was included to estimate the influence of assessment reactivity and retention incentives, given relatively high quit rates among assessment-only control participants in a previous trial.[13] This group was not included in sample size calculations or tests of statistical significance.

Recruitment, Enrollment, and Randomization

Recruitment was conducted via Instagram, Facebook, and Snapchat advertisements (eg, *Do you vape? Thinking about quitting? You may be eligible for a paid study. Click here for more info.*), which linked to the study website. Interested individuals completed online eligibility screening. Eligible individuals were emailed a link to online assent, requiring a valid email for study enrollment. Assent and passing decisional capacity launched the baseline assessment. Those who completed the baseline were assigned at random to intervention or control in a 1:1 sequence via the survey platform and instructed to confirm enrollment via text. Only those who confirmed enrollment within 24 hours were enrolled. Random assignments were concealed from participants and data collection staff. Numerous steps were taken to prevent duplicate and fraudulent enrollments (Supplement 1).

Retention

To minimize differential attrition and optimize follow-up rates, incentivized text message assessments ($5 each) regarding e-cigarette use were sent to all participants at 14 days after randomization (*Checking in: Have you cut down how much you vape nicotine in the past 2 weeks? Respond w/letter: A = I still use the same amount, B = I use less, C = I don't use at all anymore)* and monthly thereafter through 6-month follow-up (*How's the quit going? When was the last time you vaped nicotine, even a puff of someone else's? Respond w/ letter: A = In the past 7 days, B = 8-30 days ago, C = More than 30 days ago).*

Interventions

Vaping Cessation Intervention

Previously described in detail[13,16] and in eAppendix A in Supplement 2, This is Quitting is an automated, tailored, interactive text message program for vaping cessation, designed specifically for young people. It is grounded in best practices from youth smoking cessation research,[17,18] formative research with teens and young adults, and our experience

delivering digital tobacco cessation interventions. The program is anchored around constructs from social cognitive theory.[19] To reinforce perceived social norms and social support for quitting, many messages are written by other users (edited as needed). The program is tailored to a user's age, enrollment date or quit date (set/reset via text message), and vape brand. Those who do not set a quit date receive 4 weeks of messages focused on building skills and confidence. Those who set a quit date receive messages 6 weeks before and 8 weeks after their quit date that focus on the risks of vaping and benefits of quitting, exercises to build coping skills and self-efficacy, encouragement, and support. All users receive mental health support (eg, mindfulness training, self-care), breathing training, and information about Crisis Text Line. For adolescents, messages about nicotine replacement therapy describe its utility and encourage consultation with a health care professional. Keywords such as TIPS, FEELS, and STRESS deliver on-demand support. The program does not explicitly address cessation of combustible tobacco products (CTPs).

The program is available without charge and promoted nationally through the truth campaign (the antitobacco public education campaign run by Truth Initiative), earned media (unpaid media articles and interviews), and local/national outreach. Since its launch in January 2019, more than 740 000 young people (≈247 000 teens aged 13-17 years; ≈493 000 young adults aged 18-24 years) have enrolled (as of May 12, 2024). To remove potential confounding effects and ensure participant blinding, branding was removed from the program.

Assessment-Only Control

Participants received only the "retention" text messages described above. All control participants were instructed how to enroll in This is Quitting following the 7-month assessment period.

Measures

The baseline was conducted online, hosted on a secure server. Assessments at 1 and 7 months were conducted via mixed-mode follow-up (survey sent via email and text message; nonresponders contacted via telephone by research staff blinded to treatment assignment). Participants were paid $20 per survey plus $10 for responding within 24 hours of the initial invitation.

Measures validated among adolescents were used when available, with attention checks placed throughout. At baseline, demographics, multiple measures of nicotine/e-cigarette dependence, psychosocial characteristics, and other substance use were assessed to characterize the sample and explore these variables as potential moderators given their association with e-cigarette use.[2,20] Age, grade level, gender, race, ethnicity, and sexual orientation were assessed via self-report using established items[21] (eAppendix A in Supplement 2). Participants reported vaping frequency (d/mo); motivation and confidence to quit and concern about the health consequences of vaping (1 = not at all, 2 = a little, 3 = a moderate amount, 4 = a lot, 5 = very much); and past-year quit attempts.

Nicotine dependence was assessed with the 10-item Penn State Electronic Cigarette Dependence Index[22] (PSECDI; sum of items: 0-3 = not dependent, 4-8 = low, 9-12 = medium, ≥13 = high [range, 0-20]); the E-cigarette Dependence Scale[23] (EDS: 0 = never, 1 = rarely, 2 = sometimes; 3 = often; 4 = almost always; sum of items, higher score indicates greater dependence [range, 0-16]); the E-cigarette Fagerström Test of Cigarette Dependence[24] (e-FTCD; sum of items: 0-2 = low, 3-4 = low to moderate, 5-7 = moderate, ≥8 = high [range, 0-10]); and the 10-item Hooked on Nicotine Checklist[25] (HONC: sum of "yes" responses, score greater than 0 shows a loss of some degree of independence over vaping [range, 0-10]). Participants also reported perceived addiction to vaping ("very," "somewhat," "not at all," "I don't know").[26]

Two subscales of the Global Appraisal of Individual Needs-Short Screener[27] assessed internalizing disorders (4 items) and substance disorders (5 items). Per data and safety monitoring board guidance, suicidality and thought disorder items were not administered given the inability to refer participants to treatment in this digital trial. The count of past-year problems in each subscale corresponds to 3 severity levels (0 = low, 1-2 = moderate, ≥3 = high). Since the study was conducted during the COVID-19 pandemic, we administered the 4-item Roberts UCLA Loneliness Scale.[28] Responses (0 = never, 1 = rarely, 2 = sometimes, 3 = often) were summed and analyzed as a continuous variable (higher scores indicate greater loneliness [range, 0-12]).

Adverse childhood experiences (ACEs) have been linked with e-cigarette use.[29] Participants completed the 19-item Identified version of the Pediatric ACEs and Related Life Event Screener, which assesses the presence/absence of ACEs and social determinants of health.[30] Sum of ACEs indicates severity of risk (0-low, 1-3 = intermediate, ≥4 = high).[31] Participants who endorsed items regarding violence, sexual abuse, or partner abuse were instructed to call 911 or contact Crisis Text Line.

Following best practices regarding the measurement of treatment outcome in adolescent cessation trials,[32] the primary outcome was self-reported 30-day point-prevalence abstinence from e-cigarettes. Participants were instructed to consider the use of all nicotine-containing vaping devices in reporting their vaping behavior. The 7-month end point was selected to align with the measurement approach of US quitlines.[33] Repeated point-prevalence abstinence[34] was defined as no vaping in the past 30 days reported at both 1- and 7-month follow-ups. Participants also reported past 30-day use of CTPs (ie, cigarettes, little cigars, cigarillos, large cigars) at 7 months.

Sample Size

No adolescent vaping cessation studies were available to inform power calculations.[12] Therefore, the sample size calculations drew on abstinence rates from a young adult vaping cessation trial (24.1% treatment vs 18.6% control)[13] weighed against the high level of interest in quitting vaping among adolescents[8] and the lack of effectiveness of most adolescent smoking cessation interventions.[17] Thus, the study was powered to detect a treatment difference of 20% (intervention) vs 15% (control) with 80% power at 2-sided α = .05 with a randomized sample of 900 per group (1800 total) under intention-to-treat analysis. Enrollment was terminated prematurely due to budget constraints at 83.5% of target (1503/1800).

Statistical Methods

Primary outcome analyses compared 30-day point-prevalence abstinence and repeated point-prevalence abstinence at 7 months using ordinary logistic regression, as implemented in the *glm* function of R version 4.0.2.[35] The primary analysis counted each participant in their originally assigned group and used a missing-not-at-random assumption in which participants lost to follow-up were coded as treatment failures (ie, vaping). To evaluate the sensitivity of findings to this rather strong assumption,[36] a multiple imputation model was fit, in which the association between loss to follow-up and abstinence was varied over a broad range of possible values (eAppendix B in Supplement 2). In secondary analyses, inverse probability of retention weighting (IPRW) was used to correct complete case analyses (CCA) for participants' differential propensity to provide 30-day abstinence data (eAppendix C in Supplement 2). CCA produces unbiased estimates of the treatment effect under a missing-completely-at-random assumption and IPRW analyses are unbiased under a missing-at-random assumption, thus allowing examination of a broad range of possible missingness mechanisms. To explore moderators of the treatment-outcome relationship, interactions were examined between treatment assignment and variables reported in **Table 1** (eAppendix D in Supplement 2).

Post hoc analyses of CTP use outcomes were conducted at the request of the editors. Both e-cigarette and CTP use were based on a past-30-day criterion. Participants at baseline were first categorized as exclusive e-cigarette or dual users. Next, a 4-category outcome was created from 7-month data: (1) dual abstinence; (2) exclusive e-cigarette use; (3) exclusive CTP use, and (4) dual use. Dual abstinence was the category of interest. The analysis examined treatment group differences overall, among exclusive e-cigarette users at baseline and among dual users at baseline.

Results

Between October 2021 and February 2023, 19 495 individuals were screened; of these, 5717 (29.3%) were eligible and 1681 were randomized (intervention: n = 759; assessment-only control: n = 744; waitlist control: n = 178). At 1 month, the overall response rate was 83.1% (1397/1681), with slightly higher retention rates in the assessment-only (85.5% [636/744]) and waitlist (85.4% [152/178]) groups vs the intervention group (80.2% [609/759]) (P = .02). At 7 months, the overall response rate was 71.1% (1196/1681), with no difference between groups (intervention: 68.6% [521/759]; assessment-only: 73.0% [543/744]; waitlist: 74.2% [132/178]; P = .11) (**Figure**).

Table 1 reports baseline characteristics of n = 1503 participants randomized to the intervention and assessment-only groups. Average age was 16.4 (SD, 0.8) years, with most participants in 12th (38.5%) and 11th (34.4%) grade. The sample was 50.6% female, 42.1% male, 7.4% nonbinary/other; 42.5% lesbian, gay, bisexual, queer (LGBQ+); and 10.2% Black/African American, 62.6% White, 18.5% multiracial, 8.7% another race; and 16.2% Hispanic. The median number of vaping days per month was 30 (IQR, 26-30). Participants reported

Table 1. Baseline Characteristics of Enrolled Participants (N = 1503)[a]

	No. (%)[b]	
	Intervention (n = 759)	Assessment-only control (n = 744)
Demographic characteristics		
Age, mean (SD), y	16.4 (0.8)	16.4 (0.8)
Grade level	n = 757	n = 743
6th-8th	11 (1.5)	7 (0.9)
9th	28 (3.7)	29 (3.9)
10th	120 (15.9)	129 (17.4)
11th	263 (34.7)	253 (34.1)
12th	301 (39.8)	277 (37.3)
>12th	15 (2.0)	20 (2.7)
Ungraded or other grade/not a student	19 (2.5)	28 (3.8)
Gender	n = 751	n = 742
Female	386 (51.4)	369 (49.7)
Male	314 (41.8)	314 (42.3)
Nonbinary or other	51 (6.8)	59 (8.0)
Sexual orientation	n = 744	n = 734
LGBQ+	317 (42.6)	311 (42.4)
Heterosexual	427 (57.4)	423 (57.6)
Race	n = 748	n = 737
American Indian/Alaska Native	11 (1.5)	7 (0.9)
Asian	16 (2.1)	20 (2.7)
Black	76 (10.2)	76 (10.3)
Native Hawaiian or Other Pacific Islander	3 (0.4)	2 (0.3)
White	469 (62.7)	461 (62.6)
Multiracial	139 (18.6)	136 (18.5)
Other	34 (4.5)	35 (4.7)
Hispanic ethnicity	n = 750	n = 735
Yes	124 (16.5)	117 (15.9)
No	626 (83.5)	618 (84.1)
Vaping-related characteristics		
Days per month vaping, median (IQR)	30.0 (27.0-30.0)	30.0 (26.0-30.0)
Motivation to quit vaping, median (IQR)[c]	4.0 (4.0-5.0)	4.0 (4.0-5.0)
Confidence to quit vaping, median (IQR)[c]	3.0 (3.0-4.0)	3.0 (3.0-4.0)
Past year attempts to quit vaping		
None	91 (12.0)	100 (13.4)
1-2	260 (34.3)	249 (33.5)
3-5	299 (39.4)	302 (40.6)
≥6	109 (14.4)	93 (12.5)
Concern about health consequences of vaping, mean (SD)[c]	3.4 (1.1)	3.4 (1.2)
Nicotine/e-cigarette dependence		
PSECDI, mean (SD)[d]	11.9 (4.2) [n = 733]	11.7 (4.3) [n = 727]
EDS, mean (SD)[e]	9.0 (3.5)	8.9 (3.3)
e-FTCD, mean (SD)[f]	5.0 (2.2) [n = 733]	4.9 (2.3) [n = 727]
HONC, mean (SD)[g]	8.1 (2.3)	8.1 (2.2)
Vape within 30 min after waking	594 (78.3)	552 (74.2)
Perceived addiction to vaping		
Very addicted	318 (41.9)	291 (39.1)
Somewhat addicted	398 (52.4)	400 (53.8)
Not at all addicted	17 (2.2)	16 (2.2)
I don't know	26 (3.4)	37 (5.0)

(continued)

Table 1. Baseline Characteristics of Enrolled Participants (N = 1503)[a] (continued)

	No. (%)[b]	
	Intervention (n = 759)	Assessment-only control (n = 744)
Psychosocial characteristics		
GAIN-SS, median (IQR)		
Internalizing disorders[h]	4.0 (3.0-4.0)	4.0 (3.0-4.0)
Substance disorder problems[i]	3.0 (2.0-4.0)	3.0 (2.0-5.0)
RULS, median (IQR)[j]	8.0 (5.0-10.0)	8.0 (6.0-10.0)
PEARLS[k]	n = 631	n = 617
Low risk	33 (5.2)	31 (5.0)
Intermediate risk	123 (19.5)	143 (23.2)
High risk	475 (75.3)	443 (71.8)
Other substance use, past 30 d		
Cigarettes	242 (31.9)	257 (34.5)
Large cigars, little cigars, cigarillos	94 (12.4)	104 (14.0)
Nicotine pouches	74 (9.7)	86 (11.6)
Marijuana/cannabis	577 (76.0)	549 (73.8)

Abbreviations: EDS, E-Cigarette Dependence Scale; e-FTCD, e-cigarette Fagerström Test of Cigarette Dependence; GAIN-SS, Global Assessment of Individual Needs–Short Screener; HONC, Hooked on Nicotine Checklist; LGBQ+, lesbian, gay, bisexual, queer; PEARLS, Pediatric ACEs [adverse childhood experiences] and Related Life Event Screener; PSECDI, 10-item Penn State Electronic Cigarette Dependence Index; RULS, Roberts UCLA Loneliness Scale.

[a] Details about measures and response options are reported in Supplement 2.

[b] Unless otherwise noted (or when N differs from column No. due to missing values).

[c] Range, 1-5 (1 = not at all, 5 = very much).

[d] Range, 0-20 (0–3 = not dependent, 4–8 = low dependence, 9–12 = medium dependence, 13+ = high dependence).

[e] Range, 0-16 (higher score indicates greater dependence).

[f] Range 0-10 (0-2 = low dependence, 3-4 = low to moderate dependence, 5-7 = moderate dependence, 8+ = high dependence).

[g] Range, 0-10 (score greater than 0 shows a loss of some degree of independence over vaping).

[h] Number of internalizing disorder problems (of depression, sleep, anxiety, trauma) experienced in the past 12 months (range, 0-4: 0 = low severity, 1-2 = moderate severity, 3+ = high severity).

[i] Number of substance disorder problems experienced in the past 12 months (range, 0-5: 0 = low severity, 1-2 = moderate severity, 3+ = high severity).

[j] Range, 0-12 (higher score indicates greater loneliness).

[k] This measure was added to the baseline following study launch (Supplement 1). Missing data are due to timing of administration.

a strong desire to quit vaping (median, 4 [IQR, 4-5]) but less confidence about quitting (median, 3 [IQR, 3-4]). Most (87.3%) had tried to quit in the past year; 53.4% had made 3 or more quit attempts. Across measures, mean scores indicated moderate-high level of dependence: PSECDI (11.8 [SD, 4.3]); EDS (8.9 [SD, 3.4]); e-FTCD (4.9 [SD, 2.3); HONC (8.1 [SD, 2.3]); 76.2% vaped within 30 minutes of waking, and 93.6% reported feeling somewhat/very addicted to vaping. High severity was observed for internalizing disorders (mean, 3.5 [SD, 0.9]) and substance use disorders (3.0 [SD, 1.7]). Loneliness was common (mean, 7.6 [SD, 3.2), and 94.9% of participants were at intermediate (21.3%) or high risk (73.6%) for toxic stress. Item-level responses to baseline measures of nicotine dependence and psychosocial characteristics are included in eTable 1 in Supplement 2. Past 30-day use of other substances was: cigarettes, 33.2%; large cigars/little cigars/cigarillos, 13.2%; marijuana/cannabis, 74.9%; nicotine pouches, 10.6%. All standardized mean differences were below the small effect size threshold (δ = 0.20),[37] indicating balance between the intervention and assessment-only groups at baseline.

Balance was also observed between the assessment-only control and waitlist control groups at baseline; no standardized mean difference exceeded δ = 0.22[37] (eTable 2 in Supplement 2).

Vaping Cessation

As shown in **Table 2**, 30-day point-prevalence abstinence rates at 7 months in the primary analysis were 37.8% (287/759) among intervention participants and 28.0% (208/744) among assessment-only participants (relative risk [RR], 1.35 [95% CI, 1.17-1.57]; $P < .001$). Repeated point-prevalence abstinence analyses found that the intervention more than doubled quit rates compared with assessment only (RR, 2.10 [95% CI, 1.58-2.80]; $P < .001$). Multiple imputation modeling confirmed robustness of the estimates in the primary analysis (eTable 3 in Supplement 2).

Comparison of baseline characteristics between 7-month responders and nonresponders showed that male gender, Black and multiracial race, greater vaping frequency, lower confidence to quit vaping, higher nicotine dependence, higher perceived addiction, greater severity of past-year internalizing disorders, and lower past 30-day use of cigars/cigarillos were significant predictors of nonresponse ($P < .05$) after Holm multiplicity adjustment (eTable 4 in Supplement 2). After IPRW weighting, all baseline differences between responders and nonresponders fell below standardized mean difference 0.2. As expected, given nondifferential missingness across treatment groups, CCA produced more liberal estimates of intervention effects for 30-day point-prevalence abstinence (RR, 1.44 [95% CI, 1.26-1.64]; $P < .001$) and repeated point-prevalence abstinence (RR, 2.24 [95% CI, 1.70-2.94]; $P < .001$). After IPRW correction, CCA effects were slightly decreased toward levels observed in the primary analysis for 30-day point-prevalence abstinence (RR, 1.42 [95% CI, 1.24-1.63]; $P < .001$) and repeated point-prevalence abstinence (RR, 2.21 [95% CI, 1.67-2.93]; $P < .001$) (eTable 5 in Supplement 2).

The primary outcome of 30-day point-prevalence abstinence at 7 months was similar between waitlist (27.5% [95% CI, 21.5-34.6]) and assessment-only controls (28.0% [95% CI, 24.9%-31.3%]).

Moderator Results

Analyses of all variables in Table 1 as potential moderators of treatment effects on 30-day point-prevalence abstinence rates yielded no statistically significant findings after Holm multiplicity adjustment (eTable 6 in Supplement 2).

CTP Use

A total of 1016 participants had complete 7-month data on e-cigarette and CTP use (**Table 3**). Of these, 58.9% (n = 598) were exclusive e-cigarette users and 41.1% (n = 418) were dual users at baseline. At 7 months, 43.8% reported dual abstinence, 32.1% reported exclusive e-cigarette use, 3.0% reported exclusive CTP use, and 21.2% reported dual use. Combining the latter 2

Figure. Recruitment, Randomization, and Participant Flow in a Randomized Trial of a Text Message Vaping Cessation Intervention for Adolescent E-Cigarette Users

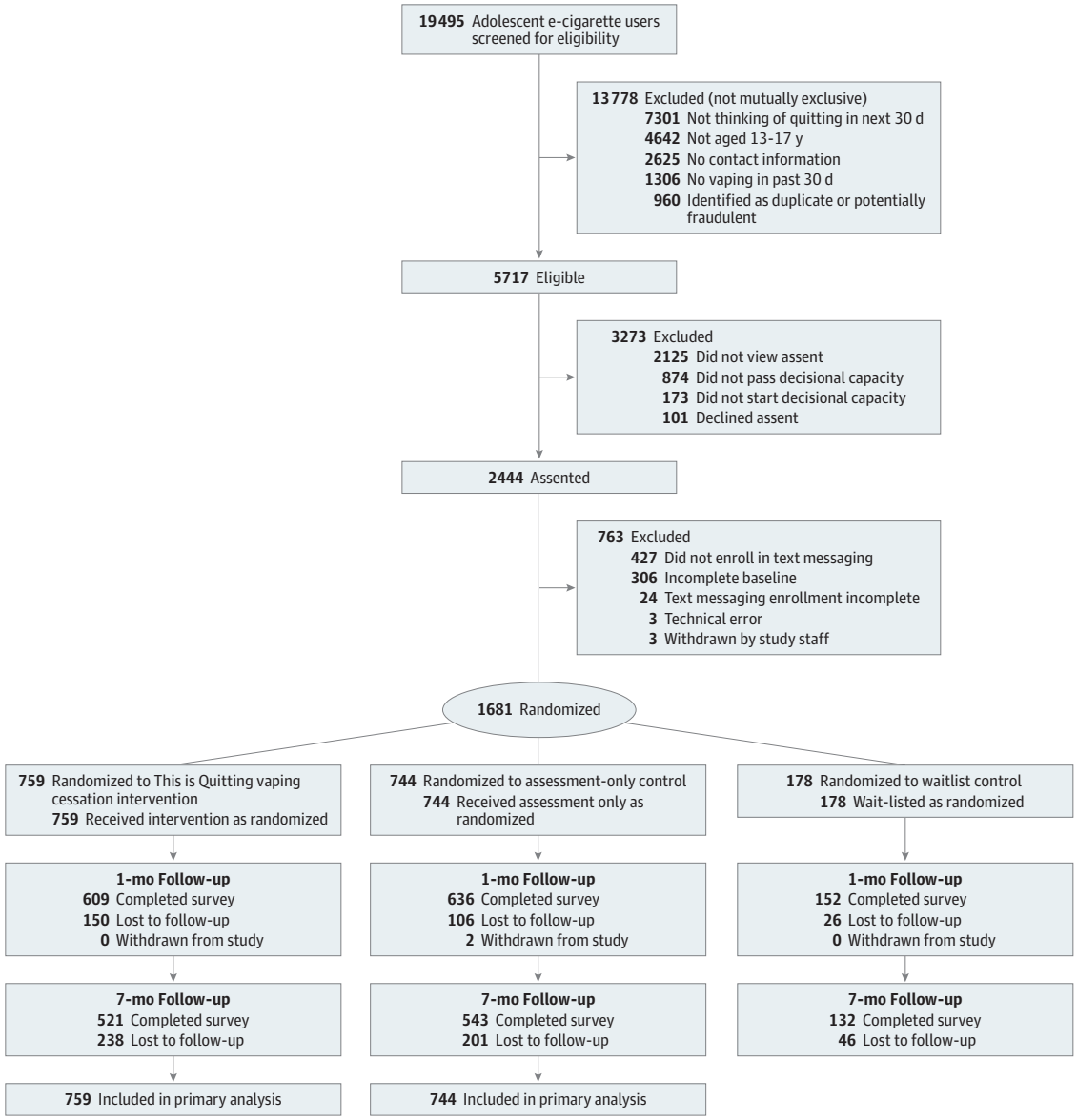

Figure depicts 2 main trial groups (This is Quitting, assessment-only control; total sample n = 1503) and a third group (waitlist control), which was included to provide context for assessment-only control. Recruitment to waitlist control was stopped early due to budget constraints.

Table 2. Vaping Cessation Outcomes at 7 Months[a]

Outcome variable (point-prevalence abstinence)	% (95% CI)			Relative risk (95% CI)	Odds ratio (95% CI)	*P* value
	Intervention (n = 759)	Assessment-only control (n = 744)	Rate difference (95% CI)			
30 d	37.8 (34.4-41.3)	28.0 (24.9-31.3)	9.9 (5.1-14.5)	1.35 (1.17-1.57)	1.57 (1.26-1.95)	<.001
Repeated	17.3 (14.7-20.1)	8.2 (6.4-10.4)	9.1 (5.7-12.4)	2.10 (1.58-2.80)	2.34 (1.69-3.22)	<.001

[a] Missing outcomes were counted as vaping.

categories, 24.1% of participants reported past 30-day CTP use at the 7-month follow-up, a percentage-point reduction of 17.0 (95% CI, 13.5-20.5; $P < .001$) from the 41.1% that reported past 30-day CTP use at baseline. A higher proportion of participants randomized to intervention reported dual abstinence (52.9%) compared with control (35.0%), a percentage-point

Table 3. Rates of E-Cigarette and Combustible Product Use at 7 Months by Treatment Assignment and Baseline E-Cigarette Use Among Adolescents Enrolled in a Vaping Cessation Randomized Clinical Trial

	No. (%)			
	Dual abstinence	Exclusive e-cigarette use	Exclusive CTP use	Dual use
Full analytic sample (n = 1016)[a]	445 (43.8)	326 (32.1)	30 (3.0)	215 (21.2)
By treatment group[b]				
Intervention (n = 501)	265 (52.9)	135 (27.0)	12 (2.4)	89 (17.8)
Control (n = 515)	180 (35.0)	191 (37.1)	18 (3.5)	126 (24.5)
Among baseline exclusive e-cigarette users (n = 598)[c]				
Intervention (n = 300)	163 (54.3)	102 (34.0)	3 (1.0)	32 (10.7)
Control (n = 298)	115 (38.6)	137 (46.0)	7 (2.4)	39 (13.1)
Among baseline dual users (n = 418)[c]				
Intervention (n = 201)	102 (50.8)	33 (16.4)	9 (4.5)	57 (28.4)
Control (n = 217)	65 (30.0)	54 (24.9)	11 (5.1)	87 (40.1)

Abbreviation: CTP, combustible tobacco product (includes cigarettes, little cigars, cigarillos, large cigars).

[a] Of n = 1503 adolescents randomized, n = 1016 reported e-cigarette and CTP use at 7 months.

[b] Subsample analyses included 501 participants randomized to intervention (66.0% of 759) and 515 randomized to control (69.2% of 744).

[c] Subsample analyses included 598 exclusive e-cigarette users (64.9% of 921) and 418 dual users (71.8% of 582).

difference of 17.9 (95% CI, 11.9-23.8; $P < .001$). This treatment advantage of intervention over control in promoting dual abstinence was observed among both exclusive e-cigarette users (54.3% vs 38.6%, $P = .001$) and dual users (50.8% vs 30.0%, $P < .001$). Among baseline exclusive e-cigarette users who quit vaping, 3.4% (n = 10) reported past 30-day CTP use at follow-up, equivalent to national rates of CTP use.[2]

Discussion

This study demonstrated the effectiveness of a tailored, interactive text message intervention for vaping cessation among adolescents. Participants randomized to This is Quitting were 35% more likely to quit vaping at 7 months compared with assessment-only control participants. Estimates of the treatment benefit appear robust to assumptions about missing data, as 7-month response rates were similar in both groups. The superiority of intervention over control was also observed in analyses of repeated point-prevalence abstinence, with intervention participants more than twice as likely to be abstinent. Treatment effects favoring the intervention group were consistent across all baseline variables examined, demonstrating the effectiveness of the intervention for vaping cessation across levels of nicotine dependence, mental health distress, and psychosocial adversity.

To our knowledge, this RCT is the first to report an effective intervention for adolescent vaping cessation. It involved a large sample that was diverse across demographic and psychosocial characteristics. The 30-day criterion for abstinence and multiple time points for follow-up aligned with recommendations for adolescent cessation studies.[32] The 70.8% retention rate at 7 months was comparable with or exceeded those of mobile phone-based smoking cessation trials among adolescents.[17,38]

The vaping cessation intervention also outperformed control in promoting dual abstinence, even though cessation of CTPs was not a focus of the intervention. Dual abstinence rates were numerically lower among baseline dual users than among exclusive e-cigarette users, but the superiority of the intervention was statistically significant among both subgroups. It may be that changes in one form of tobacco use (ie, vaping cessation) positively affected other tobacco use behaviors (ie, the decision to reject or quit CTPs). There was no evidence that adolescents who quit vaping transitioned to CTPs. Future research should explore whether addressing CTPs in a vaping cessation intervention enhances treatment effectiveness.

The magnitude of quit rates in this study is noteworthy. They exceeded quit rates from a similar trial among young adult[13] and most adolescent smoking cessation trials.[17,39] The concordance of quit rates between waitlist and assessment-only controls contravenes the possibility that they were inflated by assessment reactivity or study retention incentives. High quit rates across conditions may reflect population-based increases in risk perceptions regarding vaping[40] along with the groundswell of interest in quitting among young people,[8] driven in part by national antivaping prevention campaigns.[41,42] The trial was conducted during the COVID-19 pandemic, which may have affected quit rates.

Sample characteristics are also noteworthy. The proportion of LGBQ+ adolescents exceeds national data (42.5% vs 24.5%)[43] as does past 30-day marijuana use (74.9% vs 16%).[44] At baseline, participants in this study also reported more frequent e-cigarette use (median, 30 d/mo)[2] and higher levels of nicotine dependence across multiple measures than in other studies.[7,45] High severity of past-year problems with depression, sleep, anxiety, trauma, and substance use was also observed.[44] These characteristics may reflect targeted marketing of tobacco products to sexual minorities,[46] the treatment-seeking nature of this sample, unique and formative aspects of adolescence, and/or the effects of nicotine use and withdrawal given trends of increasing intensity of use[45] and the evolution of e-cigarettes that deliver stronger and larger amounts of nicotine.[47] With few exclusion criteria and no parental consent required, this study provides important information about the characteristics of adolescent e-cigarette users interested in quitting. The significant treatment effect observed in this study against this backdrop of risk factors underscores the power of a digital behavior change intervention to drive clinically meaningful outcomes.[18]

Text messaging is a scalable and cost-efficient approach to delivering vaping cessation treatment on a population basis. Smoking cessation intervention effects tend not to decay over time in adolescents.[39] If this holds true for vaping cessation intervention effects, this broadly accessible intervention could significantly reduce the prevalence of adolescent vaping and improve adolescent health. National guidelines recommend that pediatric health care professionals screen all adolescents for e-cigarette use. The intervention evaluated here can be a resource for clinicians whose patients express interest in quitting vaping.[48] Placing information about the intervention in clinics and waiting rooms may encourage intervention use among those who do not disclose their vaping.

Limitations

Several limitations should be noted. First, abstinence was not biochemically verified, given demonstrated challenges in digital cessation studies.[49] This was a low-intensity, fully automated intervention trial with low-demand characteristics for which biochemical verification is neither feasible nor necessary,[50] but overreporting and underreporting of abstinence are possible with adolescents.[32] Second, the intervention group may have been more affected by social desirability bias, given more touch points from the program. Third, these findings generalize to adolescent e-cigarette users interested in quitting but may not generalize to other groups. Last, analyses of mediators and changes in cannabis and alcohol use are outside the scope of this manuscript but represent important areas for further investigation.

Conclusions

A tailored, interactive text message intervention increased self-reported vaping cessation rates among adolescents recruited via social media channels.

ARTICLE INFORMATION

Accepted for Publication: May 22, 2024.

Published Online: August 7, 2024. doi:10.1001/jama.2024.11057

Author Contributions: Drs Graham and Papandonatos 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.
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Drafting of the manuscript: Graham, Jacobs, Funsten, Papandonatos.
Critical review of the manuscript for important intellectual content: Graham, Cha, Jacobs, Amato, Edwards, Papandonatos.
Statistical analysis: Graham, Funsten, Papandonatos.
Administrative, technical, or material support: Graham, Cha, Jacobs, Edwards.
Supervision: Graham, Jacobs.

Conflict of Interest Disclosures: None reported.

Funding/Support: This study was funded by Truth Initiative.

Role of the Funder/Sponsor: Truth Initiative 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.

Data Sharing Statement: See Supplement 3.

Additional Contributions: We appreciate the thoughtful guidance and oversight from the data and safety monitoring board (DSMB) members (provided pro bono): Robin Mermelstein, PhD (DSMB chair, University of Illinois at Chicago); Suzanne Colby, PhD (Brown University); Grace Kong, PhD (Yale School of Medicine); Karen Wilson, MD, MPH (University of Rochester); and Jonathan Winickoff, MD (Harvard Medical School). We are grateful for the contributions of the entire study team, including Isabel Berdecio, BS, and Ian Molloy, BS (Truth Initiative paid interns), who assisted with data collection. Last, we are indebted to the study participants for their involvement and contributions in advancing the science of vaping cessation for young people.

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